February 2. 1720-1.

At a Meeting of the *ROYAL SOCIETY*,

Sir ISAAC NEWTON, Preſident, *in the Chair*,

Mr. JONES preſented a Scheme and Specimen of an Abridgment of the PHILOSOPHICAL TRANSACTIONS, from the Year 1700 to the Year 1720. This Deſign was approved of by the SOCIETY, and he was deſired to proceed therein.

Edm. Halley, Secr. Reg. Soc.

Octob. 27. 1721.

IMPRIMATUR *Epitome* Tranſactionum Philoſophicarum, *ab Anno* 1700 *ad Annum* 1720, *a D.* Hen. Jones *compoſita.*

ISAAC NEWTON, *Reg. Soc. Præſes.*

THE

PHILOSOPHICAL TRANSACTIONS

(From the Year 1700 to the Year 1720.)

ABRIDG'D,

AND

Diſpos'd under GENERAL HEADS.

In Two VOLUMES.

By *HENRY JONES*, M. A. and
Fellow of *King*'s *College* in *CAMBRIDGE.*

VOL. IV. Containing

Part I. The MATHEMATICAL Papers.

Part II. The PHYSIOLOGICAL Papers.

The SECOND EDITION.

LONDON:

Printed for J. and J. KNAPTON, D. MIDWINTER and A. WARD, A. BETTESWORTH and C. HITCH, W. INNYS, F. FAYRAM and T. HATCHETT, J. OSBORN and T. LONGMAN, J. PEMBERTON, C. RIVINGTON, F. CLAY, J. BATLEY, and R. HETT. 1731.

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JOHN RYLANDS
UNIVERSITY
LIBRARY OF
MANCHESTER

TO THE

Right Honourable

THOMAS

Earl of MACCLESFIELD,

Lord High CHANCELLOR

OF

GREAT BRITAIN, &c.

My LORD,

AS the conſiderable Improvements, which Learning has receiv'd, are chiefly owing to the favourable Encouragement and propitious Influence of the Great; So amongſt the many Patrons of the Age there is no one, who has ſhew'd more Encouragement to it than Your Lordſhip, or who is happy in a greater Share of it.

To

To Your Lordſhip therefore, as the worthieſt Patron, I moſt humbly offer theſe Diſcourſes of the greateſt Authors; which, if they have not ſuffer'd in paſſing through my Hands, are not only highly deſerving of Your Acceptance, but ought more particularly in Honour to be inſcrib'd to Your Lordſhip's Name. For to whom could theſe Volumes be ſo properly Dedicated, as to one, who is a perfect Maſter of the Subjects here treated of? Who, like his great Predeceſſor the Lord Chancellor BACON, has taken in the wide Compaſs of Phyſical, as well as Civil Knowledge; and is throughly acquainted with the Laws of Nature, as well as thoſe of the Land? It was His Honour to lay, in ſome Meaſure, the Foundations of thoſe Improvements, which Philoſophy has ſince receiv'd; and it is the peculiar Honour and Advantage of that Philoſophy, to have fallen under Your Lordſhip's Protection in this its maturer State, in an Age abounding with uſeful Inventions and great Diſcoveries: Happy are thoſe Sciences in ſuch a Patron; they muſt certainly continue to flouriſh, when Your Lordſhip does not only encourage them by Your Liberality, but promote them by the Authority of Your own Example.

It is Matter of Surprize, my Lord, that one, whoſe whole Life has been employ'd in the active Part of the World, and in the Buſineſs of a Profeſſion very difficult and laborious, ſhould have any Inclination or Leiſure for thoſe other Parts of Learning,

Learning, which Your Lordſhip is by all allowed to poſſeſs in a very extraordinary Degree. Who, though you have receiv'd many public Addreſſes of this kind from eminent Authors, yet you have been able (ſuch are Your own natural Parts, and ſuch are Your Improvements of them) to equal thoſe Performances, you have condeſcended to patronize. In the Study of Divinity, my Lord, You may well be ſaid, to be inferiour to no one; the late Dr. HICKES has long ſince told the World, that You are a Perſon, "Who to his great Underſtanding "in our Common and Statute Laws, and in the "*Engliſh* Conſtitution before and ſince the Con-"queſt, has added ſuch a Knowledge of all the "moſt uſeful Parts of Divinity, that it is not eaſy "to determine, whether he is better skill'd in Hu-"man or Divine Laws." And I may add, who to his great Acquiſitions in the more learned Studies has join'd no leſs Attainments in the politer Arts; whoſe own Speeches on a very memorable Occaſion will tranſmit his Character as a conſummate Orator to the lateſt Poſterity. Compoſitions applauded and admired by all; and, what is the trueſt Teſt of Merit, commended by thoſe, who diſlik'd the Subject of them.

Theſe Talents ſo various, theſe Qualifications ſo uncommon, have recommended Your Lordſhip to that High Office, which You now adorn: Others have ſtruggled with great Competitors, and contending Equals in the Paths of Ambition; but in Juſtice to Your Lordſhip it is to be remember'd, that You

You were ſollicited and importun'd to accept the greateſt Truſt in the Nation.

But I muſt not preſume to detain Your Lordſhip any longer, much leſs can I pretend to do Juſtice to Your Character: And as, in preſenting You with theſe Authors, I intend a Piece of great Reſpect to Your Lordſhip; ſo I muſt eſteem it a very great Honour done to me, that any thing, in which I have had the ſmalleſt Share, can have the Favour of Your Lordſhip's Name, and obtain the Patronage of ſo good a Judge. I am,

My LORD,

Your Lordſhip's moſt Obedient,

and moſt Humble Servant,

Henry Jones.

THE

PREFACE.

THESE two Volumes being only a Continuation of a Work, which has been long ſince very well received in the World, it will be needleſs to give a minute and particular Account of my Conduct herein: It is ſufficient for me to obſerve, that I have generally followed Mr. LOWTHORP'S *Method; not only as it is a Method, the Reader is already acquainted with, but as it is a very good one: That I have endeavoured to diſpoſe of the* Papers *in as tolerable an* Order, *as ſuch a variety of independent Subjects would well admit of; that I have looked upon myſelf as, in ſome Meaſure, anſwerable for the Reputations of the ſeveral* Authors, *and do believe there is nothing omitted, but what the* Authors *themſelves would have omitted, if it had been their Buſineſs to have abridg'd them; and that upon the whole I have taken an uncommon Care and Pains in correcting the Work.*

I ſhould not have troubled the Reader with any thing more, if another Undertaking of the ſame Kind had not lately appeared in the World, performed by Mr. Motte *a* Printer, *and recommended by the learned Dr.* Halley. *I think it not improper to obſerve to thoſe, whom the Name and Character of Dr.* Halley *may influence, that his Recommendation is drawn up in general Terms,* that he had *inſpected* that Epitome, and *believes* it is done with due Care and Judgment; *and that the Recommendation is dated* July 26. 1720. before *the Work was* printed; *ſo that the* Doctor *has* no *Share in thoſe Remarks, which I may make on the* Deficiencies, Omiſſions *and* groſs Errors *of that Performance.*

As I have omitted *ſome Papers, which Mr.* Motte *has* inſerted, *I ſhall firſt mention what thoſe are, with my Reaſons for* omitting *them; and ſhall take Notice of thoſe which he has* omitted, *which are* inſerted *by me.*

I have omitted *Mr.* Cotes's Logometria, *becauſe it is now in the Preſs with ſome other Pieces of the ſame Author.*

Dr. Halley's *Synopſis of the* Aſtronomy of Comets *has been often printed, by itſelf, at the End of Mr.* Whiſton's Prælectiones Phyſico-Mathematicæ *with a Comment, and with the* Engliſh *Tranſlation of Dr.* Gregory's *Aſtronomy.*

Dr. Keill's *Theorems relating to the* Infinite Diviſibility of Matter *are printed in the* Third Edition *of his* Introductio ad veram Phyſicam.

The Account of the Contagious Diſtemper amongſt the black Cattle *in* Italy *is only an* Extract *from a* printed *Treatiſe of Dr.* Ramazzini's.

Dr. Drake's *Diſcourſe on the* Influence of Reſpiration on the Motion of the Heart *is the Subſtance of a Chapter in the* Doctor's Anatomy *of* Human Bodies.

Dr. Muſgrave's *Diſſertations, on* Britain's *having been formerly a* Peninſula, *on the* Roman *Legions, on the* Roman *Eagles, and his* Commentary *on an* Inſcription *found at* Aragon, *are printed amongſt other Pieces in the* Doctor's Collection *of* Antiquities, *in four Volumes in* Octavo.

Mr. De Moivre's *Treatiſe* De Menſura Sortis *has been publiſh'd in* Engliſh, *with conſiderable Additions and Improvements: And thoſe* Experiments *of the late Mr.* Haukſbee, *which I have omitted, are printed in the* ſecond *Edition of his* Phyſico-Mechanical Experiments. *Theſe are all the Papers* omitted *by me, which Mr.* Motte *has* inſerted.

I proceed now to inform the Reader of thoſe Papers omitted *by him, which I have* inſerted; *moſt of which are extant no where elſe, except in the Original* Tranſactions.

Mr. Craig's *Solution of a* Problem (*on* Curves) *propoſed by Mr.* John Bernoulli.

A Letter *from Monſieur* L'Abbè Conti *to Mr.* Leibnitz (*concerning the* Invention *of the* Method *of* Fluxions) *with Mr.* Leibnitz's *Anſwer.*

Dr. Gregory's *Vindication of Mr.* J. Gregory.

Dr. Taylor's *Apology for himſelf againſt* Bernoulli.

Theſe Papers, Mr. Motte *ſays, in his Preface,* were intended rather for an honeſt Repreſentation of Matter of Fact to Poſterity, than for the immediate Inſtruction of the Studious in thoſe Sciences: *Whereas I apprehend, that they were deſigned too for the* preſent Age, *and deſerved a Place in his Work, as much at leaſt as thoſe other Papers which he has inſerted, which have been ſo often* Reprinted. *But to proceed with Mr.* Motte's *Omiſſions.*

The Account of Mr. Wilſon's Pocket-Microſcope.

A Paper on the Uſefulneſs of the Obſervations *of the* Occultations *of the* fixt Stars *by the* Moon *towards finding the* Longitude.

The Invention *of making* Clocks *to keep* Time *with the* Sun's *apparent* Motion, *aſſerted by Mr.* Williamſon.

The two Experiments *of Mr.* Haukſbee's *of* firing Gunpowder *in* Vacuo, *with the next of the Deſcent of* Malt-Duſt *in* Vacuo, *are left out in* both *the* Editions *of his* Experiments.

Dr.

Dr. Wallis's *Paper on the* Invention *and* Improvements *of the* Mariner's *Compaſs.*

Mr. Haukſbee's *Experiments of the* Power *of the* Loadſtone *at* Different Diſtances *are only in the* Second *Edition of his Book of* Experiments, *and not in the* firſt; *and are* omitted *by Mr.* Motte; *I* inſerted *them becauſe they are* referred *to in the Paper which follows them.*

A Letter of Dr. Mather's *from* New-England *confirming an Account formerly given of the* Direction *of* Ship Compaſſes *being* changed *in a* Storm *of* Thunder *and* Lightning; *this I have placed in the* Chapter *of* Voyages, *amongſt ſome other* Letters *of the ſame* Author *from* New-England; *the Particulars of what I have given there in* one *Paper, are* diſpers'd *by Mr.* Motte *in* different *Parts of his Work; he might have done the ſame (if he had pleaſed) with ſome other Papers, which he himſelf has placed in the* Chapter *of* Voyages.

The next that occurs, is a Paper of Mr. Derham's, *on the* Migration *of* Birds.

The large Anatomical Account *of the* Elephant, *tho' it has been printed (as Mr.* Motte *ſays) by itſelf; yet, as it is ſome Years ſince it was printed, and on a Subject of which ſo few have wrote, it will not I hope be thought a Burden to the Reader: To that Account I have added Mr.* Lewenhoeck's *Obſervations on the* Skin *of the* Elephant, *&c.*

A Paper of Dr. Liſter's *on an Experiment of his of* powdered Blue *paſſing the* Lacteals, *is omitted by Mr.* Motte, *with this Title, A Letter from Dr.* Liſter *to Dr.* Tancred Robinſon, *commending the* Doctor's *Book on* Fevers; *whereas Dr.* Robinſon *never wrote any Book on* Fevers: *Blunders of this kind are frequent with Mr.* Motte, *and I take Notice of this only by the by.*

Mr. Lewenhoeck's *Obſervations on the* Fibres *of the* Muſcles, *and Mr.* Muys's *Obſervations on the* Texture *of the* Muſcles.

Remarks on a MS. in Phyſick *at* Florence.

The Account of an Iſland *thrown up out of the* Sea *in the* Archipelago, *by Monſieur* Bourguignon; *Mr.* Motte *ſays, moſt of the Particulars of this Paper are contained in Father* Goree's *Account of the ſame; whither they are, or not, I leave the Reader to judge.*

Mr. Lewenhoeck's *Obſervations on the* Animalcula *found on* green Weeds *growing in* Water *are inſerted by me, becauſe they are* referred *to in the* Paper *which follows them. I am ſorry that I have been forced to be ſo tedious on this Head; but it will ſave thoſe, who are deſirous of ſeeing the Difference of our Performances in this Particular, a much greater Trouble.*

And here it may not be improper to remark that in the Accounts *of* Books (*which are often given by the* Authors *themſelves*) *there are ſometimes* Corrections *and* Additions *to thoſe* Books, *extant no where but in the Original* Tranſactions; *where any thing of this Kind has occurred, I have* inſerted *it; theſe Mr.* Motte *has thought fit entirely to* omit: *the Reader need go no*

further than to the End *of the* Firſt *and* Second *Chapters for Inſtances of this Kind.*

As to the Order, *into which Mr.* Motte *has* thrown *the Papers, tho' I have many Objections to make to it, I ſhall trouble the Reader only with a few; Sufficient be it to mention, that he has placed Dr.* Keill's *Paper on the* Laws *of* Attraction, *and another on the* Infinite Diviſibility *of* Matter, *&c. under the firſt Chapter of* Geometry *and* Algebra.——*A Paper on the* Spleen *in the Chapter of the* Thorax, *which all Anatomiſts have thought fit to place in the* Abdomen.——*An Account (of Dr.* Freind's*) of an Uncommon Kind of* Convulſions, *and another of Dr.* Leigh's *on* Epileptic *Fits, (which I have placed in the* Chapter *belonging to the* Diſeaſes *of the* Head) *Mr.* Motte *has placed in the* Chapter *of* General Affections of the Body, and Caſes not reducible to any Heads. *So amongſt* Antiquities *he has placed an Account of an* Impreſſion *of a* Skeleton *in* Stone, *and ſome other Papers relating to the Changes our Earth has received, which belong to* Natural Hiſtory, *and might be placed properly enough in the Chapter of* Mineralogy: *It would be tedious to recount the many* Abſurdities *on this Head, and might perhaps to ſome ſeem too minute and trifling; who will themſelves eaſily ſee, at how* wide *a* Diſtance *he has placed many Diſcourſes, which have a* near *Relation to each other; and might have been induced to excuſe the Want of* Method, *if the Papers had not* abounded *with* Miſtakes *of* Conſequence; *and if the very* Errors *of the* Originals *had not been faithfully* tranſprinted *in this* Edition.

As to the Errors *in the* Mathematical *Part, I ſhall not mention either thoſe, which he has* copied *from the* Originals, *or thoſe of his* own *making, as it may be the Occaſion of a Diſpute, which may be carried on in an* improper *Manner, and of which every one will not be a Judge: I ſhall therefore, at preſent only mention (what is full as* material) *the Errors which occur in the* Figures *belonging to that Part of the Work.*

In the firſt *Plate, and in the* ſixth *Figure,* F *is wanting, and* c *is put for* C.——*In the* ninth *Figure* E *is wanting.*——*In the* twenty third *Figure* S *is wanting, and* T *is wanting.*——*In the* twenty fourth *Figure* I *is put for* T.——*In the* thirty fifth *Figure* O *is wanting.*——*In the* thirty ninth, l *is put for* i.——*In the* fortieth, l *is put for* i, *and B is wanting.*——*In the* forty firſt, Φ *is put for* F.——*In the* forty ſecond, f *is put for* c, *and* R *is wanting.*——*In the* Fiftieth *Figure,* O, m, n, *and the* Triangle *belonging to thoſe three Letters is left out.*——*In the* fifty ſecond, k *is left out, and* v *is put for* L.——*In the* fifty ſixth A *is left out.*——*In the* fifty eighth, (*to which* Figure *he makes no Reference in the Diſcourſe belonging to it, but refers to* Fig. 56. *by a Miſtake*) B *is wanting.*——*In the Figure marked* C (*in the ſame Plate*) F *is wanting. Theſe are* ſome *of the Faults in the* firſt *Plate only; other Plates have* as many *Faulst, it is a common Thing with Mr.* Motte, *to leave out* Letters *of* Reference, *to*

place

place others at wrong *Angles, and to put* great *Letters for the* little *ones of the ſame Signification; ſo that there are often in the* ſame *Figure two* great *Letters of the ſame Signification, when one of them ought to have been a* little *one; and ſometimes even* Lines *and* Angles *are left out.*

I chuſe rather to mention theſe Faults *of the* Figures *becauſe it has been* advertiſed (*though it is not affirm'd in the* Preface *to the Book*) *that that Edition contain'd* above ſixty Original Copper-Plates; *which, if it be meant* (*as I ſuppoſe it muſt be*) *of the* Plates *uſed in the* Original Tranſactions, *is* falſe *in* Fact.

I ſhall therefore conſider one *of theſe* Original Plates, *which ſhall be the* fifth *Plate in the* Second Part *of the Work, which conſiſts of Diſcourſes in* Anatomy *and* Phyſic. *The* Firſt, Second, *and* Third *Figures are thoſe, which were engrav'd for the* Tranſactions; *the other Figures* (*which I am to conſider*) *were new-engrav'd on the ſame Plate for the preſent Occaſion: In Page* 101. *of the* Second *Part there is an Account* of a Ball which contain'd a Plumb-ſtone within it extracted from the Anus; *three Figures are to be refer'd to, to explain this; one to ſhew the* Shape *of the* Ball *itſelf, another the* inſide *of it when it was cut into* two *Parts, and the other* Figure *the* Plumb-ſtone *which was* contain'd: *In the* Margin *Mr.* Motte *refers to* Fig. 4, 5, 6. *when there is no Figure which is number'd* 6 *in the Plate: In another Diſcourſe* (Page 104.) *to which the ſame* Plate *belongs, there is an Account of a* Stone *which was voided by* Stool, *which was ſuppos'd to have obſtructed the* Ductus communis Bilarius; *in the* Paper *itſelf he tells you, that* Y Z ſhew the Proportions exactly drawn, *when there are no ſuch Letters as* Y Z *in the Plate, and in the* Margin *refers to* Fig. 8. *which* Figure *belongs to another Paper, and is much* larger *than this* Stone; *and the* Figure, *which in this Caſe ſhould be refer'd to, has no Number at all, and is beſides much* leſs *than the* Stone *whoſe* Proportions, *he ſays,* are exactly drawn: *All this* Confuſion *ariſes from two or three Figures being not* number'd *rightly: There is another Miſtake too in this* ſame *Plate,* Page 103. *he refers to the* ſeventh *Figure, when there is no* Figure *which is* number'd 7 *in the* Plate; *the* Figure, *he ſhould have refer'd to, is number'd* 10——*I ſhall take Notice only of* one *more Fault, which is in the* Plate *belonging to* Page 248. *in the Chapter of* Aſtronomy, *where the Letter H is left out; as this belongs to a Paper of Dr.* Halley's, *Mr.* Motte, *I think, ought in* Gratitude *for his* Recommendation *to have taken more Care of it: He may ſay, this* Letter *was left out in the* Original Plate; *but this is not the only* Letter *of* Reference, *which has been* wanting *in the* Original *Plates, which I have* ſupply'd.

From the Miſtakes *of the* Plates, *I come to conſider the* Errors *Mr.* Motte *has committed in the* Papers *themſelves; and as in the former Article my Remarks were not extended beyond two or three* Plates, *ſo here* (*how* large *a*

Multitude

Multitude *ſoever preſent themſelves to my View*) *I ſhall confine myſelf to a very* few *Pages*; *and I ſhall more particularly chuſe to inſtance in a* ſmall *Number of* thoſe *Miſtakes, which happened to be ſo in the* Tranſactions *themſelves, which Mr.* Motte *has copied with great* Fidelity *and* Care. *And happy would it be for him, if* thoſe *were the* only ones *in his Performance:* His *Edition might be even* ſaid *to be* correct, *if the* Errors *of the* Originals *were the* ſmalleſt Number *in it.*——*The firſt* Paper *I ſhall pitch upon, is one of Sir* John Floyer's (*in* Part II.) *in which he has* copied *above* twenty *Errors of the* Originals; ſome *of which are as follow,* p. 207. Granum Caninum *for* Gramen Caninum, *p.* 208. Fenagreke——Zed-Oary *for* Zedoary——have a volatile Oyl, *for* have not a volatile Oyl.——Fænil——*Page* 210. *for* a Ranunculus *he puts it* aranunculus, *and in the next Page* Rapunculus.——*Page* 213. Sylveſtre Nardum *for* Sylveſtris Nardus.——Xyrs *for* Xyris.——*Page* 214. *Line* 24. *for* Fumitory, *he has* Fumaterry, *and Line* 27. Fumiterry.—*Page* 215. Violatri Color *for* Viola Tricolor.——*So in the ſame* Part *of the Work* Page 181. Line 23. *he has* in ſpaſmos inordinatos fieri *for* ferri.——*In* Part III. *Page* 211. *Line* 22. Vial *for* Wall.——*In the ſame* Part *Page* 227. *Line* 32. Eidem opinioni fovet *for* favet.——*Page* 260. *Line* 42. Exortam Turbinem.——*In* Part IV. *Page* 16. Tuque Teſtudo reſonare Septem Calida nervis; *and a little lower* Cordas *for* Chordas. *Page* 247. *Line* 31. Glandulæ Muſcoſæ *for* Mucoſæ. *I had not taken notice of* theſe *Errors, if they had not been* all *of them (amongſt a very large Number of* greater *Conſequence*) Errors *in the* Originals *themſelves: And I entirely ſubmit it to the Judgment of the Reader, how* capable *Mr.* Motte *muſt be of publiſhing* ſuch *a Work* correct, *who has* copied *Errors ſo* groſs *and* glaring, *and ſo eaſily to be* diſtinguiſh'd. *No one can think me under any* Obligations *to correct any* more *of his Miſtakes: By what I have already mentioned, I have given him an Opportunity of correcting* ſome, *as particularly thoſe of the* Plates; *which, as they may be* ſoon *corrected and alter'd, I deſire the Reader (who has thoſe Books already) to take Notice, that thoſe Faults are there at* preſent. *Mr.* Motte *in his* Preface (*as if conſcious of his Errors*) *in order to excuſe* the Imperfections of his Work, *pleads the* Number of Papers, and Variety of Subjects; *I am very ready to admit of his Excuſe: And* (*as I have found the* Latin *Papers more faulty than the reſt*) *I beg leave to offer another, The* Variety of Languages. ——— *Nor is even the* low *Work of his* Indexes *free from* Miſtakes: *In the* Index *of the* Authors Names, *as he had given to ſome* wrong Titles, *ſo he has left out near* twenty *Names entirely.*

But that Part of his Management *of this Work, to which I could make the* moſt *Objections, is what I muſt not give myſelf leave to make* any *Remarks upon; which is, the* unwarrantable Liberty *he has taken in* ſome *Papers of* omitting *ſome things, which I think deſerved more Regard than he has paid to them. But, as it might give Offence to others, I muſt deſiſt*

from being particular on that Head: Tho' I can with great Conſiſtence at the ſame Time affirm, that I might *have taken the Liberty of* omitting *ſome things which I have* inſerted, *if I had not thought that I had met with an Adverſary, who would place his chief Merit in* reprinting *all that came to his Hands.*

And now I think it is high Time to come to a Concluſion, and to make an End of this ungrateful *Taſk of* Criticiſing: *And as in making thoſe Remarks, which I thought* neceſſary, *I have abſtain'd from all* perſonal Reflections, *and have confined myſelf to* thoſe, *which more* immediately *ariſe from the* Performance *itſelf; ſo I ſhould not have been ſo* free *as I have been in my* Animadverſions, *if Mr.* Motte *had not ſpoke of me in his* Preface *in ſuch Terms, as I think I have a juſt Exception to. I have ſaid, I think, enough, to ſatisfy thoſe, who have not ſeen his Performance; and to thoſe, who have but* looked *into it, all that I have ſaid is needleſs: And as the World has been* beforehand *with me in their* Cenſure *of this Work, I ſhall leave him to enjoy thoſe imaginary* Advantages, which may accrue to himſelf and the Public from his Performance (*Preface*, p. 5.) *Neither ſhall I any farther indulge the ill-natured Pleaſure of triumphing over an expired* Author.

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THE

THE
Philoſophical Tranſactions
ABRIDG'D.

PART I.

Containing the

Mathematical PAPERS.

CHAP. I.

Geometry, Arithmetic, Algebra, Logarithmotechny.

I. IT has heretofore paſſed for a current Maxim, That all Infinites are equal.

The Poſition nevertheleſs is certainly erroneous, as Dr. *Halley* abundantly has ſhown in the *Philoſophical Tranſactions* for *October* 1696. He there gives divers Inſtances of infinite Quantities which are in a determinate finite Proportion one to another, and ſome infinitely greater one than another.

The like may be obſerved of infinitely ſmall Quantities, *viz.* Mathematical Points, as the following Propoſition will make appear.

The Proportion *of Mathematical* Points *to each other by the Hon.* Fr. Robartes, n. 334. p. 470. Vid. ſupra Vol. I. C. I. S. XXV.

PROP. I.] *The Points of Contact between Circles and their Tangents, are in ſubduplicate Proportion to the Diameters of the Circles.*

Fig. 1. Let two Circles *a d c h*, *a f b g*, touch one another from within at the Point *a*. Draw the Tangent *p a q*, and parallel to it the Line *m n*. From the Point *a* draw the Diameter *a c*.

Let *a c*, the Diameter of the great Circle, be equal to *R*, and *a b*, the Diameter of the leſſer Circle, be equal to *S*.

Let *d h*, the Chord of the Arch *d a h*, be equal to *z*, and *f g*, the Chord of the Arch *f a g*, be equal to *y*, and let the Abſciſs *a k* be equal to *x*.

If the Line *m n* be ſuppoſed to move till it becomes co-incident with the Tangent *p a q*, the Nature of a Circle will always give the following Equations.

$$zz = 4Rx - 4xx$$
$$yy = 4Sx - 4xx$$

When the Line is arrived at the Tangent, *z* and *y* will become the two Points of Contact; and then $zz = 4Rx$ and $yy = 4Sx$. ($4xx$ being laid aſide as heterogeneous to the reſt of the Æquation, by reaſon of *x* being become infinitely little.) Therefore

$$zz . yy :: 4Rx . 4Sx :: R . S.$$
$$\text{Therefore } z . y :: \sqrt{R} . \sqrt{S}. \quad Q. E. D.$$

PROP. II.] *The Point of Contact between a Sphere and a Plane, is infinitely greater than that between a Circle and a Tangent.*

Fig. 2. Let *a* be the Point of Contact between the Sphere *a d q f* and the Plane *b c*. About the Sphere deſcribe the Cylinder *n p g m*.

Draw *k h* to repreſent a Circle parallel to the Plane. Let the Circle be ſuppoſed to move, till it becomes co-incident with the Plane. The Cylindrical Surface *k h g m* will always be equal (according to *Archimedes*) to the Spherical Surface *d a f*.

Now when theſe Surfaces become infinitely ſmall, one terminates in the Point of Contact, and the other in the Periphery of the Baſe of the Cylinder. Therefore the Point of Contact is equal to the Periphery of the Baſe of the Cylinder (equal to a Periphery which has the ſame Diameter as the Sphere) and by Conſequence is infinitely greater than any Point of Contact between a Circle and a Tangent. *Q. E. D.*

PROP. III.] *The Points of Contact by Spheres of different Magnitude are to one another as the Diameters of the Spheres.*

For by the ſecond Propoſition the Points of Contact are equal to the Peripheries of ſuch Diameters, whoſe Proportion is the ſame as the Diameters. *Q. E. D.*

Some Properties *of* Conic *Sections deduced from the Nature of* Focus's *by Mr.* Abr. de Moivre, n: 352. p. 622. Fig 3.

II. Sit *D E* Axis Tranſverſus Ellipſeos, *A O* Axis alter, & *C* Centrum Sectionis. Sit *P* punctum quodvis in circumferentia ejus; *P Q* Tangens curvæ ad *P*, occurrens Axi Tranſverſo ad *Q*; puncta *S*, *F*, Foci; *C P*, *C K*, Semidiametri Conjugatæ; *P H* Semilatus rectum ad Diametrum *P C*; *P G* normalis ad Tangentem, cui occurrat *H G*, perpendicularis ipſi *P C H*, in puncto *G*, ut fiat *P G* radius Curvaturæ Ellipſeos in puncto *P*: ſint etiam *S T*, *C R*, *F V*, perpendiculares in Tangentem *P Q* demiſſæ: Jungatur *S O*, & demittatur in Axem normalis *P L*. His poſitis Dico quod,

1. *Rectangulum ſub diſtantiis ab utroque Ellipſeos Foco ſive* S P × P F *æquale eſt quadrato Semidiametri* C K.

Demonſtratio.

$PSq = PCq + CSq - 2CS \times CL$ per 13. II. Elem.
$PFq = PCq + CSq + 2CS \times CL$ per 12. II. Elem.
Unde $PSq + PFq = 2PCq + 2CSq$.
Jam $PS + PF = DE = 2CD$; ac propterea
$PSq + PFq + 2PS \times PF = 4CDq$.
Quare tranſponendo, $2PS \times PF = 4CDq - 2PCq - 2CSq$.
Ac dimidiando $PS \times PF = 2CDq - PCq - CSq$.
Eſt autem *CS quad.* $= CD$ *quad.* $-$ *CO quad.* atque adeo
$PS \times PF = CDq + COq - PCq$.
Sed $CDq + COq = PCq + CKq$. *per* 12, VII. *Conic. Apollonii.*
Quare $PS \times PF = CKq$. *Q. E. D.*

2. *Diſtantia à Foco S P eſt ad perpendicularem in Tangentem demiſſam, ut Semidiameter Conjugata C K ad Semiaxem minorem C O.*

Demonſtratio.] Ob ſimilia Triangula *S P T*, *F P V*, erit $PS : PF :: ST : FV$; ac componendo $PS + PF$ erit ad $ST + FV$, & earundem dimidia *C D* ad *C R*, ut *P S* ad *S T*. Unde $CD \times CK$ erit ad $CR \times CK$ ut *PS* ad *S T*. Sed $CR \times CK$ æquale eſt rectangulo ſub Semiaxibus *C D* in *CO*, per 31. VII. *Conic.* Proinde *P S* eſt ad *S T* ut *C D* in *C K* ad $CD \times CO$, ſive ut *CK* ad *C O*. Ac pari argumento demonſtrabitur *P F* eſſe ad *F V* in eadem ratione. *Q. E. D.*

3. *In eadem etiam eſt ratione Semiaxis Tranſverſus C D ad normalem è centro C ad Tangentem demiſſam, ſive ad C R.*

Etenim cum rectangulum $CR \times CK$ æquale ſit rectangulo $CD \times CO$, uti jam dictum eſt, erit ἀνάλογον *C D* ad *C R* ut *C K* ad *C O*. *Q. E. D.*

4. *Semidiameter quævis P C eſt ad diſtantiam puncti P à foco S, ſive ad S P, ut diſtantia ab altero Foco F P ad dimidium lateris recti ad Verticem P pertinentis, ſive ad P H.*

Hoc autem manifeſtum eſt ob *Propr.* I. cum nempe quadratum ex *C K* æquale ſit rectangulo ſub $SP \times PF$.

5. *Rectangulum Semiaxium* $CD \times CO$ *eſt ad quadratum ſemidiametri conjugatæ* CK, *ut* CK *ad Radium Curvaturæ in puncto* P, *ſive ad* PG.

Sunt enim Triangula PCR, PGH inter ſe ſimillia, unde CR eſt ad PC, ut ſemilatus rectum PH ad PG: hoc eſt, per præmiſſam Proprietatem III, $\frac{CD \times CO}{CK} = CR$ eſt ad PC ut $\frac{CK^2}{PC} = PH$ ad $\frac{CK^2}{CD \times CO} = PG$, proinde ἀνάλογον $CD \times CO : CK^2 :: CK : PG$. *Q. E. D.*

THEOREMA GENERALE 1.] *Vis centripeta ad idem punctum* S *tendens, in Curvis omnibus, eſt ſemper proportionalis Quantitati* $\frac{SP}{PG \times ST^3}$

Hoc Theorema ante plures annos à me inveſtigatum & cum amicis communicatum, propriis demonſtrationibus firmavere Geometræ Clariſſimi D. *J. Bernoullius* in *Act. Lipſiæ*; D. *J. Keillius* in harum *Tranſact.* N. 317. & D. *Jac. Hermannus in Phoronomiâ*, ſuâ, pag. 70. quos vide.

Vid. *infra* C. IV. S. V.

Scribendo autem CK^2 pro PG, per *Propr.* V; & $\frac{SP}{CK}$ juxta *Propr.* II. pro ST; (ob datas ſcilicet CD, CO) erit Vis centripeta tendens ad focum Ellipſeos S, ſemper ut $\frac{SP \times CK^3}{CK^2 \times SP^3}$, hoc eſt ut $\frac{SP}{SP^3}$ vel $\frac{1}{SP^2}$, nempe reciprocè ut quadratum ex SP. Unde patet quod ſi Sectio fuerit Ellipſis motu corporis deſcripta, erit Vis Centripeta ut quadratum diſtantiæ à centro Virium reciprocè. Ex his Proprietatibus conſequuntur Corollaria nonnulla notatu non indigna.

Coroll. 1.] *Velocitas Corporis in Ellipſi revolventis, ad punctum quodlibet* P, *eſt ad Velocitatem revolventis in circulo ad eandem diſtantiam* SP *à centro Virium, in ſubdupla ratione diſtantiæ ab altero foco* PF, *ad Semiaxem tranſverſum Sectionis, ſive ut media proportionalis inter* PF *&* CD *ad* CD.

Eſt enim velocitas revolventis in Ellipſi ad diſtantiam SP, ad Velocitatem revolventis in Circulo vel Ellipſi ad diſtantiam Semiaxis CD vel SO, ut CO ad ST; hoc eſt per *Propr.* II. ut $\sqrt{PF}$ ad $\sqrt{SP}$. Velocitas autem revolventis in Circulo ad diſtantiam CD eſt ad velocitatem revolventis in Circulo ad diſtantiam SP, ut $\sqrt{SP}$ ad $\sqrt{CD}$. Ex æquo igitur Velocitas revolventis in Ellipſi ad diſtantiam SP, eſt ad Velocitatem revolventis in Circulo ad eandem diſtantiam ut $\sqrt{PF}$ ad $\sqrt{CD}$.

Coroll. 2.] *Ex datis Velocitate in Ellipſi, poſitione Tangentis, & centro Virium ſeu Foco, facile eſt determinare Focum alterum.*

Sit enim Velocitas Data R; ea autem Velocitas quâ deſcriberetur Circulus ad datam à centro diſtantiam SP ſit Q; ac per *Coroll.* præcedens, R eſt ad Q ut $\sqrt{PF}$ ad $\sqrt{CD}$, adeoque QQ eſt ad RR ut CD ad PF, & $2QQ - RR$ erit ad RR ut SP ad PF: Datur autem SP; data eſt igitur PF magnitudine. Datur etiam poſitione, ob angulum VPF angulo SPT æqualem. Datur igitur punctum F alter Focorum: Quo invento pronum eſt Sectionem deſcribere. Si

Si vero $\frac{1}{2} RR$ majus fuerit quadrato ex $\mathcal{Q}$, $2\mathcal{Q}\mathcal{Q}-RR$ fit quantitas Negativa, & loco Ellipſeos Trajectoria deſcribenda in Hyperbolam tranſit. Eritque $RR-2\mathcal{Q}\mathcal{Q}$ ad RR ut SP ad PF diſtantiam alterius Foci, ad alterum Tangentis latus ponendam, ut habeatur Focus F. Proprietates autem omnes quas in Ellipſi demonſtravimus; mutatis mutandis etiam Hyperbolæ competunt.

Quod ſi acciderit $\mathcal{Q}\mathcal{Q}$ æquale eſſe dimidio quadrati ex R; evaneſcente quantitate $2\mathcal{Q}\mathcal{Q}-RR=o$, quarta proportionalis PF fit infinita: proinde Trajectoria deſcribenda Parabolica eſt, Foco ſcilicet altero in infinitum abeunte. Axis autem Trajectoriæ poſitione datur; eſt enim ipſi PF parallelus, exiſtente ſcilicet angulo FPV angulo dato $SP\mathcal{T}$ æquali. Fig. 4.

Coroll. 3.] *Velocitas revolventis in data Sectione Conica ad diſtantiam SP eſt ad Velocitatem ejuſdem ad diſtantiam aliam SX, ut media proportionalis inter FP & SX ad mediam proportionalem inter SP & FX.*

Velocitas enim in P eſt ut $\sqrt{\frac{FP}{SP}}$ (per *propr.* II.) & per eandem, Velocitas in X eſt ut $\sqrt{\frac{FX}{SX}}$. Unde manifeſta eſt propoſitio.

Coroll. 4.] *Ratio etiam Velocitatum duorum Corporum in eodem Syſtemate, ſed in datis Coniſectionibus diverſis, revolventium, datis utriuſque à communi Orbium Foco diſtantiis, ope Corollarii 1^mi, ſtatim obtinebitur.*

Cum enim Velocitas corporis in P ſit ad velocitatem in Circulo ad eandem diſtantiam SP, ut $\sqrt{PF}$ ad $\sqrt{CD}$; & in alia ſuppoſita Coniſectione, cujus Semiaxis cd & Foci Sf, ad diſtantiam Sp Velocitates illæ ſint ut $\sqrt{pf}$ ad $\sqrt{cd}$; Velocitas autem revolventis in Circulo ad diſtantiam SP ſit ad Velocitatem in Circulo ad diſtantiam Sp ut $\sqrt{Sp}$ ad $\sqrt{SP}$; Compoſitis rationibus, erit Velocitas in P ad Velocitatem in p, ut $\sqrt{PF\times cd\times Sp}$ ad $\sqrt{pf\times CD\times SP}$. Quod ſi Sectio illa altera fuerit Parabola, erunt cd, pf infinitæ, ſed in ratione 1 ad 2; proinde ratio Velocitatum erit ut $\sqrt{PF\times Sp}$ ad $\sqrt{2CD\times SP}$.

Coroll. 5.] *Quod ſi in Hyperbola punctum P abeat in infinitum, ex præcedentibus manifeſtum eſt, Velocitatem ultimam ac minimam, qua cum corpus in æternum aſcenderet, equalem eſſe ei qua, ad diſtantiam* CD *Semiaxi tranſverſo æqualem Circulum deſcriberet.*

Coroll. 6.] *Ex data diſtantia à Foco, datur quoque Poſitio Tangentis, ſive angulus $SP\mathcal{T}$, ſub diſtantia SP & Tangente $P\mathcal{T}$ contentus.*

Eſt enim (per *prop.* II.) PS ad $S\mathcal{T}$ ut CK ad CO ſive ut $\sqrt{SP\times PF}$ ad CO, atque ita Radius ad Sinum anguli $SP\mathcal{T}$. At in Ellipſibus Circulis affinibus præſtaret angulum $PS\mathcal{T}$, ejuſdem complementum ad quadrantem, inquirere: Hujus autem Sinus eſt ad Radium ut $\sqrt{SP\times PF-CO^q}$ ad $\sqrt{SP\times PF}$.

Coroll.

Coroll. 7.] *Atque hinc conſequuntur Velocitates quibuſcum diſtantiæ SP creſcunt vel decreſcunt.*

Nam cum, ex Corollario præcedente, $\sqrt{SP \times PF}$ ſit ad $\sqrt{SP \times PF - CO^q}$ ut radius ad ſinum anguli PST, ac in eadem ſit ratione Velocitas Corporis in P ad Velocitatem momenti ipſius SP; Velocitas autem illa in P ſit (per *propr.* II.) ut $\sqrt{\frac{PF}{SP}}$; eliſis ſuperfluis, erit $\frac{\sqrt{SP \times PF - CO^q}}{SP}$

Velocitati, qua creſcit vel decreſcit diſtantia SP, ſemper proportionalis.

THEOREMA GENERALE II.] *In omni Trajectoria Curvilinea Velocitates angulares circa centrum Virium ſunt reciprocè proportionales quadratis diſtantiaram à centro.*

Nam ob Sectorum minimorum Areas æquales, arcus angulis minimis ſubtenſi ſive Baſes, ſunt reciprocè ut Radii. Anguli autem minimi quibus Baſes æquales ſubtenduntur ſunt etiam reciprocè ut Radii. Proinde anguli Sectorum minimorum Areâ æqualium, ſunt inter ſe reciprocè in dupla ratione Radiorum, ſive ut quadrata diſtantiarum.

Coroll. 8.] *Hinc Velocitates angulares revolventium in diverſis Ellipſibus datis comparantur inter ſe.*

Velocitates enim angulares quibuſcum ad diſtantias Semiaxibus Tranſverſis æquales circuli deſcriberentur, ſunt reciprocè in ratione ſeſquialtera Axium, ſive ut $\frac{1}{CD\sqrt{CD}}$. Velocitates autem angulares has mediâs habent Corpora revolventia, cum quadrata diſtantiarum æquantur rectangulis ſub ſemiaxibus Ellipſeôn. Ideo (per *Theor.* II.) erit SP^q ad $CD \times CO$ ut $\frac{1}{CD\sqrt{CD}}$ ad $\frac{CO}{SP^q \times \sqrt{CD}}$: quæ quidem Quantitas eſt ut Velocitas anguli ad centrum S, motu rectæ SP, tempore quam minimo dato, deſcripti.

Coroll. 9.] *Velocitas angularis qua circumgyratur Tangens PT, ſive recta in Tangentem perpendicularis ST, eſt ad Velocitatem angularem rectæ SP, ut Semiaxis tranſverſus CD ad diſtantiam ab altero Foco PF.*

Fig. 5. *Demonſtratio.*] Sint puncta P, p, quam proxima inter ſe; ductiſque SP, Sp, ſint PT, pt duæ Tangentes, ad quas demittantur normales ST, St; iiſque parallelæ ducantur radii Curvaturæ PG, pG, coeuntes in G: ac deſcribatur, centro S & radio SP, arcus minimus PE occurrens ipſi Sp in E. Manifeſtum eſt angulum PGp æqualem eſſe angulo TSt, ſive angulari Velocitati normalis ST. Eſt autem angulus PSp angularis velocitas rectæ SP; quare angulus PGp eſt ad angulum PSp ut angularis Velocitas ipſius ST ad angularem velocitatem rectæ

rectæ SP; hoc eſt, ut $\frac{Pp}{PG}$ ad $\frac{PE}{PS}$. Sed $Pp . PE :: SP . ST :: CK : CO$ (per *propr.* II.) Hæ igitur Velocitates ſunt ut $\frac{CK}{PG}$ ad $\frac{CO}{PS}$. Pro PG ſcribe $\frac{\dot{CK}}{CD \times DO}$ (per *propr.* V.) ac $\frac{CK}{PG}$ fiet $\frac{CD \times CO}{CKq} = \frac{CD \times CO}{PS \times PF}$. Hinc $\frac{CD \times CO}{PS \times PF}$ erit ad $\frac{CO}{PS}$, ſive, deletis ſuperfluis, CD ad PF, ut angulus TSt ad angulum PSp, ſive Velocitas angularis Tangentis ad angularem Velocitatem diſtantiæ SP: proinde Velocitas qua circumgyratur Tangens, ſemper proportionalis eſt quantitati $\frac{CO \times \sqrt{CD}}{PF \times SPq}$.

Pleraque horum Corollariorum ex aliis Conicarum Sectionum Proprietatibus deducta, vel facile deducenda, inveniet Lector in Sect. III. Lib. I. Princip. Nat. Philoſophiæ.

III. Tangentium methodum propono, (è *Maximorum* & *Minimorum* Theoria immediatè deductam) facilem ſatis ac generalem, imo generaliſſimam, utpote curvis omnibus unâ eâdemque operâ inſervientem. Neque novam vocare metuo, cùm celebriorum Geometrarum nullus (in quantum unquam ſcire potui) aliquid hujus generis publici juris fecit. Pauca tantum ejus ſpecimina hîc in medium profero. *Tangents to Curves, &c. by Mr.* H. Ditton, n. 284. p. 1333.

Sit Curva AGH, cujus vertex A, axis AK, ordinatim applicata FD centrumque (ſi quod habet) punctum K. Sumpto puncto L in Axe ſit $AL = n$, $AD = x$, $FD = y$, $FL = z$; quarum quantitatum, tres poſteriores ſunt fluentes, prior verò n permanens ac ſtabilis, hæc enim una eademque prioribus variis ſemper reſpondet. Ex Triangulo Rectangulo FDL, hanc habemus Equationem, $zz = yy + nn - 2nx + xx$; determinandoque z ad extremum, oritur $2y\dot{y} - 2n\dot{x} + 2x\dot{x} = 0$; unde interpretando $2y\dot{y}$ ſecundum propriam Curvæ naturam, relinquetur quantitas n expoſita in terminis etiam Curvæ propriis. Fig. 6.

Cùm verò z hoc modò ad valorem extremum determinatam habeamus; hoc eſt, linea FL omnium quæ a puncto L ad Curvam duci poſſunt vel maxima vel minima ſit, indeque ad Curvam in puncto F normalis; ipſam DL eſſe ſubnormalem patet, ex quâ ſubtangens nullo negotio eruitur.

In exemplum producatur primò Parabola *Apolloniana*, quàm curvam hîc delineatam eſſe ſupponemus. Habemus ergo $2y\dot{y} = r\dot{x}$ (poſito Parametro $= r$) unde $r\dot{x} - 2n\dot{x} + 2x\dot{x} = 0$, & $n = \frac{r}{2} + x$, ergoque

DL

D L ſubnormalis $= \frac{1}{2}$ r. (Cujus Theorematis ſenſus hîc eſt, viz. Si ultra terminum D abſciſſæ A D, deſinetur D L ſemiparametro equalis, atque à puncto L producatur L F recta ad punctum F; recta ſic ducta Parabolæ in puncto F normalis erit, & omnium quæ à puncto L, ad Curvam duci poſſunt minima. Dico minimam; alicui enim curvæ naturam ac indolem ſcienti, apparet Maximam eſſe non poſſe (id quod in ſequentibus notatum velim) ſed neceſſario eſt vel maxima vel minima, ideoque Poſterior.) Hæcque pars prior eſt Theor. 5. Lib. 7. Conicor. Præclariſſimi *de la Hire*.

Ducatur ordinata E B, junganturque puncta E, L; ſit intercepta B D $= f$, unde A B $= x - f$, & B L $= \frac{r}{2} + f$. Jam L E $^{q} = \frac{rr}{4} + rx + ff$, & F L $^{q} = \frac{rr}{4} + rx + ff$, & F L $^{q} = \frac{rr}{4} + rx$, ergo L E ^{q} — F L ^{q} = B D ^{q}; quæ pars poſterior eſt Theorem. 5. ejuſdem Lib. Conicor.

Quò propriùs punctum F in quo curvam normalis ſecat, puncto A ſive vertici admovetur; eò propiùs etiam punctum L eidem venit. Ergo quando F cum A coincidit, & ſic evaneſcit ordinata F D, tunc ipſa Minima jacet in Axe A K, & ſemiparametri quantitatem adequabit. Hoc eſt in illo caſu $n = \frac{1}{2} r$ tantum; in nihilum abeunte x abſciſſâ ad ordinatam evaneſcentem pertinente. Si ergo A L $= n = \frac{1}{2} r$, ſumpto puncto D inter A & L, fiat A D $= x$; tum oritur F L $^{q} = \frac{rr}{4} + xx$, ergo F L ^{q} — A L $= xx$, hoc eſt F L ^{q} — A L ^{q} = A D ^{q} — ſemper. Ejuſdemque tenoris eſt Theor. 2. Lib. 7. Conicor. *de la Hire*.

Secundò ſit curva quædam ordinis Parabolici ſuperioris, cujus æquatio $r^{\frac{p-q}{p}} x^{\frac{q}{p}} = y$.

Tum $yy = r^{\frac{2p-2q}{p}} x^{\frac{2q}{p}}$, adeoque

$2yy = \frac{2p}{p} r^{\frac{2p-2q}{p}} x^{\frac{2q-p}{p}} \dot{x}$; ſubſtituendoque hunc valorem loco $2y\dot{y}$ in æquatione generali determinante z ad extremum, habemus

$\frac{2p-2q}{p}$ $\frac{2q-p}{p}$

inde $n=\frac{q}{p}r$ & $+x$; & propterea ſubnormalis

$\frac{2p-2q}{p}$ $\frac{2q-p}{p}$

$DL=\frac{q}{p}r$ & : Hoc verò ſingulis hiſce curvis facillimè applicatur, ſi indices p & q ſecundum unius cujuſque naturam ac genium debito modo exponantur.

Supponetur tertiò Curvam eſſe Ellipſin cujus $\frac{1}{2}$ Axis majoris AK; ex cujus etiam æquatione conſequitur $2y\dot{y}=r\dot{x}-\frac{2rx\dot{x}}{q}$. Unde provenit $r\dot{x}-\frac{2rx\dot{x}}{q}-2n\dot{x}+2x\dot{x}=o$, & $n=\frac{r}{2}+x-\frac{r\dot{x}}{q}$, ac propterea $\frac{r-rx}{2\ q}$ ſubnormali DL equalis. Si vero ellipſeos loco ſubſtitueretur Circulus, æquationem eodem modo tractando, inveniemus $DL=r-x$, poſito r Circuli Radio æquali.

Sed ad Ellipſin revertendum, cujus alia proprietas ex hoc fonte deducenda eſt, prout in Parabolâ factum.

Sit $BD=f$, unde $AB=x-f$. Habemus LE^q $(=LB^q+EB^q)$ $=\frac{rr}{4}-\frac{rrx}{q}+\frac{rrxx}{qq}+ff+rx-\frac{rxx}{q}-\frac{rff}{q}$: & FL^q $(=FD^q+LD^q)=rx-\frac{rxx}{q}+\frac{rr}{4}-\frac{rrx}{q}+\frac{rrxx}{q\ q}$: Ergo, $LE^q-LF^q=ff-\frac{rff}{q}$; Hoc verò eſt Theor. 6. Lib. 7. Conic. *de la Hire.*

Poſtulat enim Geometra ille ſublimis, ut ſit $q.\ r.\ \frac{q}{2}-x:LD$, cujus valor eſt $\frac{r-rx}{2\ q}$ prout ſupra inventum; ideoque quarta proportionalis

nalis eſt tribus ante poſitis: Hoc verò ei conceſſo, L F eſſe minimam omnium rectarum quæ à puncto L ad Ellipſin duci poſſunt evidenter demonſtrat. Præterea quoniam eſt $q : q-r :: f : f-\frac{fr}{q}$. Ergo $\square$ $ff-\frac{rff}{q}$ ſive $f \times \frac{fr}{q}$, idem eſt quòd rectangulum apud D *de la Hire* exemplar vocatum: Hoc verò exemplar ſecundum ejus definitionem, eſt Rectangulum ſimile Rectangulo, differentiam inter Quadratum Axis Tranſverſi & Figuram conſtituenti (hoc eſt Rectangulo $qq-qr$) & præterea ad Rectam B D ſive f applicatum. Et quòd Rectangulum $ff-\frac{rff}{q}$ omnes haſce conditiones poſſideat, Luce Meridianâ clarius eſt.

Notetur, ex valore quantitatis n ſupra invento, planè conſequi $n > \frac{r}{2}$. Nam $n = \frac{r}{2} + x + \frac{rx}{q}$, ergo $qn + rx = \frac{qr}{2} + qx$, ſed (propter $q > r$) $qx > rx$, ergo, $qn > \frac{qr}{2}$, & $n > \frac{r}{2}$.

Quando (ut in Parabola modò obſervatum) punctum F in A verticem incidit, ipſa Minima in Axe deſignatur; & propter evaneſcentem x, habemus $n = \frac{1}{4}$: Aſſumptoque quovis puncto D inter A & L, ſi A D = alicui x, comparando emergit F L q A L q $= xx - \frac{rxx}{q}$; quòd ipſum eſt Theor. 3. Lib. VII. Conic. D. *la Hire*. Quoniam enim eſt $q : q-r :: x : x-\frac{rx}{q}$, patet $\square$ $xx-\frac{rxx}{q}$ eſſe exemplar, ſed applicatum ad abſciſſam x; & præterea hoc eſſe menſuram adæquatam defectûs, quadrati Minimæ à quadrato cujusvis rectæ alterius, ab eodem puncto ad curvam protenſæ; hæcque demonſtrat ille loco citato.

Theoremata verò ad Axem minorem ſive conjugatum ellipſeos ſpectantia (hactenus enim majore ſive Tranſverſo uſi fuimus) eodem planè modo determinantur. Sit jam A K $\frac{1}{2}$ Axis Minoris $= \frac{c}{2}$, Parameter = R; punctum L jam ultra centrum, ad alteras partes G K collocari ſupponitur. Operando ut priùs, invenietur A L ſive $n = \frac{R}{c} + x - \frac{Rx}{2}$, & ſubnormalis D L $= \frac{R}{c} - \frac{Rx}{2}$; Hoc eſt

c: R :: $\frac{c}{2} - x : \frac{R}{2} - \frac{Rx}{c}$, adeoque ductâ F L omnium quæ à puncto L ad ellipſin duci poſſunt Maxima, & $LF^q - LE^q = \frac{Rff}{c} - ff =$ Rectangulo exemplar ad B D (ſive f) applicato. Quod verò hoc ſit exemplar, patet, eſt enim c: R $- c$: : f: $\frac{Rf}{c} - f$, adeoque ex definitione, $\frac{Rf}{2} - f \times f =$ Exemplari. Hoc verò Theor. eſt 7. Lib. 7 Conicor. *De la Hire.*

Iterum; Punctō F cum A coincidente: propter evaneſcentem x evaneſcentis tunc temporis ordinatæ, relinquitur $n = \frac{R}{2} -$, & AL omnium quæ à puncto L ad Ellipſin duci poſſunt maxima, & $AL^q - FL^q = \frac{Rxx}{c} - xx =$ Exemplari ad A D ſive x applicato; eodemque modo ſonat Theor. 4. Lib. prædicti Conicorum.

Obſervandum verò ad caſum præcedentem (quòd priùs ergo notari debuit) ubi invenimus

$n = \frac{R}{2} + x - \frac{Rx}{c}$, quòd $n < \frac{R}{2}$; nam $cn + Rx = \frac{Rc}{2} + cx$ & propter $R > c$, adeoque $Rx > cx$, relinquitur $cn < \frac{Rc}{2}$, & $n < \frac{R}{2}$.

Jam verò ut res in Ellipſi peracta eſt, ſic eodem prorſus modo in Hyperbola peraganda foret, minimæque in hâc curvâ lineæ determinandæ: ſed talis inter haſce curvas connectio, tam faciliſque ab unâ ad alteram tranſitus, ut vel Tyronibus ipſis labor inanis videatur. Nil aliud reſtat, v. gr.
ad ſubnormalem determinandam, quàm ut ſignum — in + mutetur.

Nam cùm in Hyperbolâ ſit $2yy = r\dot{x} + \frac{2rx\dot{x}}{q}$, & $n = \frac{r}{2} + x + \frac{rx}{q}$ (æquatione generali) manet $DL = \frac{r}{2} + \frac{rx}{q}$.

Concipietur Quarto Curvam M S N (in altera Fig. parte delin.) Eſſe unam ex Hyperboloidibus, cujus Aſymptoti A K, K H, rectamque S R ad Aſymptoton K H ordinatam, S R ſit $= y$, S P $= z$, K R $= x$. K P $= n$, quæ hîc neceſſariò minor erit quàm x, ut conſideranti patet. Æquatio curvæ propria eſt $y^p x^q = r^q s^p$ cujus loco (propter r & s quantitates determinatas) ſcribi poſſit $y^p = x^{-q}$, adeoque

$y^2 = x^{\frac{-2q}{p}}$, & $2y\dot{y} = -\frac{2q}{p}\dot{x}x^{-\frac{2q-p}{p}}$; hinc cum

$zz = yy + xx - 2nx + nn$, pro extremo habemus

$2y\dot{y} + 2x\dot{x} - 2n\dot{x} = o$; hoc eſt $-\frac{2q}{p}\dot{x}x^{-\frac{2q-p}{p}}$

$+ 2\dot{x}\dot{x} = 2n\dot{x}$, & $n = x - \frac{q}{p}x^{-\frac{2q-p}{p}}$

adeoque ſubnormalis P R $(= x - n) = \frac{q}{p}x^{-\frac{2q-p}{p}}$

Curvam jam A F G (ultimo loco) Cycloiden primariam concipiamus; ſitque r Radius, c Arcus, & y ordinata Circuli genitoris, cujus Diameter per A K repræſentatur centrumque inter L & K poſitum. Tum vocatâ F D Cycloidis ordinatâ a, cæteriſque ut priùs; curvæ æquatio eſt $aa = yy + 2cy + cc$, adeoque zz $(= aa + nn - 2nx + xx) = yy + 2cy + cc + nn - 2nx + xx$, & ($z$ ad extremum determinatâ) $2y\dot{y} + 2c\dot{y} + 2y\dot{c} + 2c\dot{c} - 2n\dot{x} + 2x\dot{x} = o$,

Eſt verò $\dot{y} = \frac{r\dot{x} - x\dot{x}}{y}$, & $c = \frac{r\dot{x}}{y}$, ergo hos valores ſubſtituendo, ac

æquationem debitè reducendo, habemus $2r - x\frac{2rc - 2xc}{y} + 2r + \frac{2cr}{y} = 2n - 2x$; ac propterea $2r - x + \frac{2rc - xc}{y} = n - x =$

D L ſubnormali

Incom-

Incomparabilis D. *Barovius* ſubtangente præcognitâ, ad Maximum & Minimum determinandum utitur; hocque idem poſt eum fecit D. *Newentiit* in ſuâ infinitorum Analyſi. Cùm verò multis aliis Methodis, in quibus nihil omnino de Curvarum Tactione præſupponitur, Maximum ac Minimum inveniri queant, palàm eſt è Maximis & Minimis ad Tangentes determinandas, tutò ac legitimè procedere poſſe.

COROLL. I.] Exempla hactenus oblata percurrenti, in ſingulis vis patebit, quòd $2\dot{y}\dot{y} - 2n\dot{x} + 2x\dot{x} = o$, poſito nempè loco n in hâc æquatione valore ejus ſecundum curvæ naturam. In Hyperboloidibus

$$\frac{2q-p}{p} \qquad \frac{2q-p}{p}$$

ergo ex. gr. $\frac{2q}{p}\dot{x}x \qquad -2x\dot{x} + \frac{2q}{p}\dot{x}x \qquad +2xx = o,$

quòd (ipſo oculo judice) manifeſtum eſt; & ſic in aliis (ſine ullâ demonſtratione) veritas facilè perſpicietur.

COROLL. II.] Ex ſubnormalium inventione, curvarum ordinatas Maximas & Minimas facile determinabimus. Hâcque in re dico, ſi ſubnormalis (pro aliquo curvæ puncto) nihilo ponatur æqualis, habemus ordinatam iſtius curvæ ad extremum determinatam; & quidèm maximam ſi ad partes curvæ concavas, minimam verò ſi ad convexas applicari intelligatur. Ex. gr. in Circulo (poſitâ ſubnormali $= l$) eſt $l = r - x$; ſit $r - x = o$; ergo $r = x$, ac $y = r$, hoc eſt applicata maxima Radio æqualis. Similiter in Ellipſi, $l = \frac{r}{2} - \frac{rx}{q}$; ſit $\frac{r}{2} - \frac{rx}{q} = o$, tum $rq = 2rx$, ac $x = \frac{q}{2}$, ergo $yy = \frac{rq}{4} =$ 4tæ parti Figuræ (uti vocant) ſive ſemiaxis conjugati quadrato, adeoque maxima $y =$ iſti ſemiaxi. Nec Methodo diſſimili cùm aliis curvis operandum foret; inveniatur ſubnormalis ex æquatione datâ, eâque nihilo æquali poſitâ, ordinatam curvæ maximam vel minimam determinatam habebimus; priorem ad partem curvæ verſus axem concavam, poſteriorem ad convexam.

POSTSCRIPTUM.

Primò æquè facilè hâc methodo determinari Tangentem, ad partes curvæ convexas operando, ac ad partes concavas uti priùs. Sit enim

A C Tangens verticalis inque eâ ad libitum ſumpto puncto C, ſit A C = n, C O = z (quò etiam charactere omnes lineæ, a puncto C ad curvam convexam A E G ductæ, inſigniantur) ergo ductâ M O ſemper ad A C perpendiculari, erit C M = $n - y$, & cùm O M = x, erit $zz = nn - 2ny + yy - xx$, adeoque (pro extremo ipſius z valore) $2y\dot{y} + 2x\dot{x} - 2n\dot{y} = o$. In quâ æquatione ſi exponatur $2x\dot{x}$ ſecundum curvæ naturam, lineam C Z (quæ hoc loco ſubnormalis vicem ſubibit) determinatam dabimus. Res clarior eſt quàm quæ exemplis illuſtrantibus indigeat; quæque jamjam dicta ſunt facile hoc opus excuſabunt.

Secundò, Sicut Methodo priore, (Curvarum Tangentes invenimus) ipſius lineas L E vel C O à puncto dato vel in Axe vel in Tangente verticali ſumpto productas, ad extremum determinando; ſic etiam conſiderando lineas Q E, &c. à puncto in Axe dato ultra verticem productas, idem (idque univerſaliter) perficere poſſumus. Omnes enim lineæ Q E valoris fluentis ſunt ac perpetuò mutabilis, ſola verò Tangens Q F poſito quòd Q F curvam tangat) ſtabilis eſt ac ad unicum valorem determinata. Hoc ergo loco, τῦ extremi Hypotheſi non innitemur, ſed quantitatem permanentem tantum ſpeculabimur. Aſſumantur duo puncta Q L, indeque ad idem curvæ punctum E duæ ſemper lineæ ducantur L E, Q E, inter Punctum F contactus ac verticem, angulus Q E L ſemper erit obtuſus, ad alteras verò partes puncti F acutus erit, ſuppoſito (quòd priùs monitum) Q F curvam tangere, ac F L ei ad angulos rectos inſiſtere. Sit Q A = p. A L = n. A B = x. B E = y. Q E = z. V E (intercepta inter punctum E & V ubi cadit Q V perpendicularis ab Q in L E productam) = v. Jam propter Triangulum obtuſangulum Q E habemus hanc æquationem $zz = p^2 + 2pn - y^2 - x^2 + \overline{-y^2 + n^2 - 2nx + xx}\,|^{\frac{1}{2}} \times 2v$; ſive loci $\overline{y^2 + n^2 - 2nx + xx}\,|^{\frac{1}{2}}$ ſcribendo f,

eſt $zz = p^2 + 2pn - y^2 - x^2 + 2nx - 2fv$. ideoque

$2z\dot{z} = y\dot{y} - 2x\dot{x} + 2n\dot{x} - 2f\dot{v} - 2v\dot{f}$.

Si z jam fiat quantitas ſtabilis, quò in Caſu Q E cùm Q F tangente coincidet, erit tum

$-2y\dot{y} - 2x\dot{x} + 2n\dot{x} = o$ (Rectangulo $2fv$ ejuſque adeo fluxione penitus evaneſcente.) Hæc verò eſt ipſa æquatio Generalis Methodo ſuperiori determinata, quæque uti videmus non minus facilè, ac naturaliter, ex hoc ſuppoſito quantitatis ſtabilis principio, quam ex illo *extremi* deducitur.

IV. Sit

IV. Sit *A* Area Curvæ cujus Abſciſſa x, & ordinatim Applicata $x^m\sqrt{dx-xx}$. Sit *B* Area Curvæ cujus Abſciſſa eadem cum priori, ſed ordinatim Applicata $x^{m-n}\sqrt{dx-xx}$; ponatur $\sqrt{dx-xx}=y$. Erit Area = *A Method of Squaring ſome kinds of Curves, by Mr.* Abr. de Moivre, n. 278. *p.* 1113.

$$d^n B \text{ in } \frac{2m+1}{2m+4} \text{ in } \frac{2m-1}{2m+2} \text{ in } \frac{2m-3}{2m} \text{ in } \frac{2m-5}{2m-2} \&c, = P$$

$$-\frac{1}{m+2}\, x^{m-1}\, y^3 = -Q$$

$$-\frac{d}{m+1} \text{ in } \frac{2m+1}{2m+4} x^{m-2}\, y^3 = -R$$

$$-\frac{dd}{m} \text{ in } \frac{2m+1}{2m+4} \text{ in } \frac{2m-1}{2m+2} x^{m-3}\, y^3 = -S$$

$$-\frac{d^3}{m-1} \text{ in } \frac{2m+1}{2m+4} \text{ in } \frac{2m-1}{2m+2} \text{ in } \frac{2m-3}{2m} x^{m-4}\, y^3 = -T \&c.$$

Ubi notandum 1° quod n ſupponitur numerus integer & affirmativus; 2° quod Quantitas $d^n B$ in ſerie per P deſignata, multiplicari debet in tot terminos quot ſunt unitates in n; 3° quod tot ſequentes ſeries per $-Q$, $-R$, $-S$, $-T$, &c. deſignatæ ſumi debeant, quot ſunt unitates in n; quod ut Exemplo uno vel altero clarius fiat, dico quod ſi $n=1$, tunc A

$$= d^n B \text{ in } \frac{2m+1}{2m+4} - \frac{1}{m+2}\, x^{m-1}\, y^3 \text{ \& ſi } n=2,$$

$$A = d^n B \text{ in } \frac{2m+1}{2m+4} \text{ in } \frac{2m-2}{2m+2} \frac{1}{m+2}\, x^{m-1}\, y^3$$

$$- \frac{d}{m+1} \text{ in } \frac{2m+1}{2m+4} \text{ in } x^{m-2}\, y^3$$

4° quod ſi y ponatur $=\sqrt{dx-xx}$, tunc A erit $=Q-R+S-T$, &c. $\pm P$.

COROLL.

COROLL. I.] Si m ponatur æqualis termino cuivis ſequentis

Seriei $-\frac{1}{2}, \frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \frac{7}{2}, \frac{9}{2}$, &c.

quadraturaCurvæ cujus ordinatim Applicata $x^m\sqrt{dx-xx}$, aut $x^m\sqrt{dx+xx}$ finita evadit & exhibetur per ſeriem noſtram; quod ut Exemplo illuſtretur, Inquirenda ſit Area Curvæ cujus ordinatim applicata $x^{-\frac{1}{2}}\sqrt{dx-xx}$; fingatur Curvam hanc comparari cum Curva cujus ordinatim Applicata $x^{-\frac{1}{2}}\sqrt{dx-xx}$, quoniam hoc in caſu $n=1$, ideo

$$A=d^n\,B\,in\,\frac{2m+1}{2m+4}-\frac{1}{m+2}x^{m-1}\,y^3$$

ſed $m=-\frac{1}{2}$, ergo $2m+1=0$, ideoque

$$A=-\frac{1}{m+2}x^{m-1}\,y^3=-\frac{2y^3}{3\sqrt{x^3}}$$

Hic obſervatu dignum eſt quod Area ſic reperta interdum data quantitate deficit a vera Area, aut eandem data quantitate excedit; quo autem exceſſus iſte aut defectus innoteſcat ſupponatur Area reperta augeri minuive data quantitate q, tuncque poſita $x=0$, ſupponatur Area aucta minutave æqualis nihilo, ſic in præſenti caſu q reperietur

$=\frac{2}{3}d\sqrt{d}$, adeoque

$$A=\frac{2}{3}d\sqrt{d}\qquad\frac{2y}{3\sqrt{x^3}}$$

COROLL. II.] Si n ponatur æqualis termino cuivis ſequentis ſeriei 3, 4, 5, 6, 7, &c. Quadratura Curvæ cujus ordinatim applicata $x^{-n}\sqrt{dx-xx}$, aut $x^n\sqrt{dx+xx}$, finita evadit, & exhibetur per Seriem noſtram; Inquirenda ſit Area Curvæ cujus ordinatim applicata $x^{-3}\sqrt{dx-x}$, finge eam comparari cum Area Circuli, quæ vocetur A; erit $m=0$, $n=3$, adeoque $A=P-Q-R-S$. Sed cum Quantitas $2m$ infinite parva ſeu potius nulla, in Denominatore termini tertii per quem $d^n\,B$ multiplicatur, extet, Quantitas deſignata per P infinita

infinita eſt; atque ob eandem cauſam, Quantitas deſignata per $-S$ infinita evadit, adeoque Quantitates A, $-Q$, $-$ evaneſcunt: Igitur $P = S$,

diviſaque æquatione per $\frac{2m+1}{2m+4}$ *in* $\frac{2m-1}{2m+2}$ fit

$$d^n B \text{ in } \frac{2m-3}{2m} = \frac{dd}{m} x^{m-3} y^3 \quad \text{ſeu } d B \text{ in } \frac{2m-3}{2}$$

$= dd x^{m-3} y^3$: ſcriptiſque 0 & 3 pro m & n prodibit

$$d B \text{ in } -\frac{3}{2} = \frac{y^3}{x^3}, \text{ ſeu } B = -\frac{2y^3}{3x^3},$$

COROLL. 3.] Si m ponatur æqualis termino cuivis ſequentis ſeriei, -2, -1, 0, 1, 3, 4, 5, &c. Quadratura Curvæ, cujus ordinata $x^m \sqrt{dx-xx}$, pendet a Quadratura Circuli: Area vero Curvæ cujus ordinata $x^m \sqrt{dx+xx}$, pendet a Quadratura Hyperbolæ, & relatio iſtius Curvæ cum Circulo aut Hyperbola exhibetur per Seriem noſtram in terminis finitis.

COROLL. 4.] Si m exponatur per alium quemvis terminum differentem ab iis quas ſupra memoravimus, Curva cujus ordinata $x^m \sqrt{dx-xx}$, aut $x^m \sqrt{dx+xx}$, neque quadratur exacte, nec ab Hyperbola aut Circulo pendet, ſed ad Curvam ſimpliciorem reducitur per ſeriem noſtram.

THEOREMA 2.] Sit A Area Curvæ cujus Abſciſſa x & ordinatim applicata $\frac{x^m}{\sqrt{dx-xx}}$, Sit B Area Curvæ cujus Abſciſſa eadem cum priori ſed ordinatim applicata $\frac{x^{m-1}}{\sqrt{dx-xx}}$ ponatur $\sqrt{dx-xx}$, $= y$. Erit $A = \sqrt{dx-xx}$,

$$d^n B \text{ in } \frac{2m-1}{2m} \text{ in } \frac{2m-3}{2m-2} \text{ in } \frac{2m-5}{2m-4} \text{ in } \frac{2m-7}{2m-6} \&c. = P.$$

$$-\frac{1}{m} x^{m-1} \qquad y = -Q.$$

$$-\frac{d}{m-1}in\frac{2m-1}{2m}x^{m-2}\quad y=-R$$

$$-\frac{dd}{m-2}in\frac{2m-1}{2m}in\frac{2m-3}{2m-2}x^{m-3}\quad y=-S$$

$$-\frac{d^3}{m-3}in\frac{2m-1}{2m}in\frac{2m-3}{2m-2}in\frac{2m-5}{2m-4}x^{m-4}\quad y=-T\ \&c.$$

Obſervationes ad primum Theorema, hic & in ſequentibus Locum habent.

COROLL. 1.] Si m ponatur æqualis Termino cuivis ſequentis ſeriei, $\frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \frac{7}{2}, \frac{9}{2}$, &c. quadratura Curvæ cujus ordinatim applicata $\frac{x^m}{\sqrt{dx-xx}}$ aut $\frac{x^m}{\sqrt{dx+xx}}$ finita evadit, & exhibetur per hanc ſeriem.

COROLL. 2.] Si n ponatur æqualis Termino cuivis ſequentis ſeriei 1, 2, 3, 4, 5, 6, 7, &c. Curva omnis cujus ordinatim applicata $\frac{x^{-n}}{\sqrt{dx-xx}}$ aut $\frac{x^{-n}}{\sqrt{dx+xx}}$ quadratur per hanc ſeriem in terminis finitis.

COROLL. 3.] Si m exponatur per terminum quemlibet ſequentis ſeriei, 0, 1, 2, 3, 4, 5, 6, 7, &c. Curva cujus ordinatim applicata $\frac{x^m}{\sqrt{dx-xx}}$ pendet a quadratura Circuli. Curva verò cujus ordinatim applicata $\frac{x^m}{\sqrt{dx+xx}}$, a quadratura Hyperbolæ. Etenim ſi Centro C, Diametro $AB=d$ deſcribatur Circulus AEB, ac ſumatur $AD=x$; erecto DE normaliter, junge CE. Sector AEC per $\frac{1}{8}dd$ diviſus æqualis eſt

Fig. 7.

Areæ Curvæ cujus Ordinata $\frac{x^o}{\sqrt{dx-xx}}$ Eodem modo, ſi Centro C, Tranſverſo axi $AB=d$ deſcribatur æquilatera Hyperbola AE, ſumatur $AD=x$, erigatur DE ad angulos rectos, jungatur CE; ſector ACE per $\frac{1}{8}dd$ diviſus æqualis eſt Areæ Curvæ cujus ordinata $\frac{x^o}{\sqrt{dx+xx}}$. Fig. 8.

COROLL. 4.] Si m ponatur æqualis Termino cuivis, qui non in limitationes præcedentes cadat, Curva cujus ordinata $\frac{x^m}{\sqrt{dx+xx}}$ neque quadratur exacte, nec a Circulo aut Hyperbola pendet, ſed ad Curvam ſimpliciorem reducitur.

THEOREMA 3.] Sit A Area Curvæ cujus Abſciſſa x, ordinatim applicata $x^m\sqrt{rr-xx}$, ſit B area Curvæ cujus Abſciſſa itidem x, ordinatim applicata $x^{m-2n}\sqrt{rr-xx}$ ponatur $\sqrt{rr-xx}=y$. Erit. $A=$

$$r^{2n}B \text{ in } \frac{m-1}{m+2} \text{ in } \frac{m-3}{m} \text{ in } \frac{m-5}{m-2} \text{ in } \frac{m-7}{m-4} \text{ in } \&c. = P.$$

$$-\frac{1}{m+2}\,x^{m-1}\,y^{3} = -Q$$

$$-\frac{rr}{m} \text{ in } \frac{m-1}{m+2}\,x^{m-3}\,y^{5} = -R$$

$$-\frac{r^4}{m-2} \text{ in } \frac{m-2}{m+2} \text{ in } \frac{m-3}{m}\,x^{m-5}\,y^{7} = -S, \&c.$$

COROLL. 1.] Si m exponatur per terminum quemvis ſequentis ſeriei 1, 3, 5, 7, 9, *&c.* Quadratura Curvæ cujus ordinata $x^m\sqrt{rr-xx}$ aut $x^m\sqrt{rr+xx}$ finita evadit, & exhibetur per hoc Theorema.

COROLL. 2.] Si n exponatur per terminum quemvis ſequentis ſeriei 2, 3, 4, 5, 6, *&c.* Curva cujus ordinata $x^{-2n}\sqrt{rr-xx}$ aut $x^{-2n}\sqrt{rr+xx}$, quadratur exacte per hoc Theorema.

COROLL. 3.] Si m exponatur per Terminum quemvis ſequentis ſeriei — 2, 0, 2, 4, 6, 8, *&c.* Quadratura Curvæ cujus ordinata $x^m\sqrt{rr-xx}$, pendet a Circulo. Quadratura vero Curvæ cujus ordinata $x^m\sqrt{rr+xx}$, pendet ab Hyperbola.

COROLL. 4.] Si m exponatur per Terminum quemvis differentem ab illis quos ſupra memoravimus, Curva cujus ordinata $x^m\sqrt{rr-xx}$, aut $x^m\sqrt{rr+xx}$, neque exacte quadratur, nec a Circulo aut Hyperbola pendet, ſed ad ſimpliciorem Curvam reducitur.

THEOREMA 4.] Sit A Area Curvæ cujus abſciſſa x, ordinatim applicata $\frac{x^m}{\sqrt{rr-xx}}$, Sit B Area Curvæ cujus Abſciſſa itidem x, Ordinatim applicata $\frac{x^{m-2n}}{\sqrt{rr-xx}}$ Erit $A =$

$$r^{2n}\,\mathrm{B}\,in\,\frac{m-1}{m}\,in\,\frac{m-3}{m-2}\,in\,\frac{m-5}{m-4}\,in\,\frac{m-7}{m-6}\,\&c. = P.$$

$$-\frac{1}{m}x^{m-1} \qquad y = -Q$$

$$-\frac{rr}{m-2}\,in\,\frac{m-1}{m}\,x^{m-3} \qquad y = -R$$

$$-\frac{r^4}{m-4}\,in\,\frac{m-1}{m}\,in\,\frac{m-3}{m-2}\,x^{m-5} \qquad y = -S$$

$$-\frac{r^6}{m-6}\,in\,\frac{m-1}{m}\,in\,\frac{m-3}{m-2}\,in\,\frac{m-5}{m-4}\,x^{m-} \qquad y = -T.\ \&c.$$

COROLL. 1.] Si m exponatur per terminum quemvis ſequentis ſeriei 1, 3, 5, 7, 9, *&c.* Quadratura Curvæ cujus ordinata

x^m

$\frac{x^m}{\sqrt{rr-xx}}$ aut $\frac{x^m}{\sqrt{rr+xx}}$, per hoc Theorema habetur in finitis Terminis.

COROLL. 2.] Si n exponatur per terminum quemlibet sequentis seriei 1, 2, 3, 4, 5, 6, *&c.* Curva cujus ordinatim applicata

$\frac{x^{-2n}}{\sqrt{rr-xx}}$ aut $\frac{x^{-2n}}{\sqrt{rr+xx}}$ exacte quadratur per hoc Theorema.

COROLL. 3.] Si m exponatur per terminum quemvis sequentis seriei 0, 2, 4, 6, 8, 10, *&c.* Quadratura Curvæ, cujus ordinatim applicata $\frac{x}{\sqrt{rr-xx}}$ pendet a quadratura Circuli. Etenim si Centro C radio $CA=r$ describatur Circulus AEG, sumatur $CD=x$, erigatur DE normalis ad CD, Jungatur CE, Sector CAE per $\frac{1}{2}rr$ divisus æqualis est Areæ Curvæ cujus ordinatim applicata $\frac{x^0}{\sqrt{rr-xx}}$. Eodem modo si Centro C, Transverso semiaxi $CA=r$, describatur æquilatera Hyperbola EAM, ducatur CF ad AC perpendicularis $=x$, ducatur FE axi parallela donec occurrat Hyperbolæ in E, jungatur CE : sector Hyperbolicus ACE per $\frac{1}{2}rr$ divisus æqualis est Areæ Curvæ cujus ordinatim applicata $\frac{x^0}{\sqrt{rr+xx}}$.

COROL. 4.] Si m exponatur per terminum quemlibet a præcedentibus differentem, Curva cujus ordinata $\frac{x^m}{\sqrt{rr-xx}}$ aut $\frac{x^m}{\sqrt{rr+xx}}$ neque quadratur exacte, nec a Circulo aut Hyperbola pendet, sed ad Curvam simpliciorem reducitur.

THEOREMA 5.] Sit A Area Curvæ cujus abscissa x, ordinatim applicata $\frac{x^m}{d-x}$; sit B Area Curvæ cujus abscissa itidem x, ejusq; ordinatim

appli-

applicata $\frac{x^{m-n}}{d-x}$ Erit Area

$$A = d^n\ B - \frac{x^m}{m} - \frac{d x^{m-1}}{m-1} - \frac{d d x^{m-2}}{m-2}\ \&c.$$

Sit ordinatim applicata $\frac{x^m}{d+x}$, tunc Area erit =

$$A = \frac{x^m}{m} - \frac{d x^{m-1}}{m-1} + \frac{d d x^{m-2}}{m-2}\ \&c.\ \mp d^n\ B.$$

COROLL.] Si m exponatur per terminum quemlibet sequentis seriei, 0, 1, 2, 3, 4, 5, 6, &c. Quadratura Curvæ cujus ordinatim applicata

Fig 9. $\frac{x^m}{d-x}$, aut $\frac{x^m}{d+x}$ pendet a quadratura Hyperbolæ; Etenim ductis DE, EF ad angulos rectos, sumatur $EG = d$, ducatur GH normalis ad EF & ipsi æqualis. Intra Asymptotos DE, EF, describatur Hyperbola per H transiens, quo facto sumatur $GK = x$ versus E pro primo casu, at versus F pro secundo; ducatur ordinatim applicata KL: Area $HGKL$ per dd divisa æqualis est Areæ Curvæ cujus ordinatim applicata $\frac{x^0}{d-x}$, aut $\frac{x^0}{d+x}$. Hinc Solidum generatum a portione Cissoidis dum circa diametrum Circuli genitoris revolvit, in finitis terminis exhibetur, data Hyperbolæ Quadratura.

THEOREMA 6.] Sit A Area Curvæ cujus abscissa x, ordinatim applicata $\frac{x^m}{rr+xx}$; Sit B Area Curvæ cujus abscissa itidem x, ordinatim applicata $\frac{x^{m-1n}}{rr+xx}$ Erit Area

$$A = -\frac{x^{m-1}}{m-1} - \frac{rr x^{m-3}}{m-3} + \frac{r^4 x^{m-5}}{m-5}\ \&c.\ \mp r^{1n} B.$$

COROLL.

COROLL.] Si m exponatur per terminum quemlibet ſequentis Seriei 0, 2, 4, 6, 8, &c. Quadratura Curvæ cujus ordinatim applicata $\frac{x^m}{rr+xx}$ pendet a rectificatione circularis Arcus. Etenim ſi centro C radio $CA=r$ deſcribatur Circulus AEG, ducatur Tangens $AK=x$, jungatur CK, peripheriæ occurrens in E; arcus AE per rr diviſus æqualis eſt Areæ Curvæ cujus ordinata $\frac{x^o}{rr+xx}$.

Corollarium generale ad hæc ſex Theoremata.

Curva omnis mechanica cujus Quadratura pendet ab aliqua è Curvis numero infinitis, cujus ordinatæ formas ſequentes adipiſci poſſunt

$$x^m\sqrt{dx\pm xx},\quad \frac{x^m}{\sqrt{dx\pm xx}};\quad x^m\sqrt{rr\pm xx}\quad \frac{x^m}{\sqrt{rr\pm xx}}$$

$\frac{x^m}{d\pm x}$, $\frac{x^m}{rr+xx}$, per ſeries has quadrari poteſt. Hoc Exemplo unico indicare ſatis erit.

Poſito quod Cubus Arcus Circularis Sinui verſo correſpondentis fiat Ordinata Curvæ, cujus Abſciſſa ſit idem Sinus verſus. Inquirenda eſt Area iſtius Curvæ,

Sit abſciſſa x, Arcus circularis v, fluxio Areæ fit $v^3\dot{x}$,

Sit Area v^3x-q. Igitur $v^3\dot{x}+3v^2\dot{v}x-\dot{q}=v^3\dot{x}$,

unde $\dot{q}=3v^2\dot{v}x$; ſed $\dot{v}=\frac{d\dot{x}}{2\sqrt{dx-xx}}$, igitur $\dot{q}=\frac{3dv^2x\dot{x}}{2\sqrt{dx-xx}}$,

ſed per Theorema II. $\frac{x\dot{x}}{\sqrt{dx-xx}}=\frac{d\dot{x}}{2\sqrt{dx-xx}}-\dot{y}=\dot{v}-\dot{y}$,

adeoque $\dot{q}=\frac{1}{2}dv^2\dot{v}-\frac{1}{2}dv^2\dot{y}$, igitur $q=\frac{1}{2}dv^3-\int\frac{1}{2}dv^2\dot{y}$.

Ergo ad hoc perventum eſt ut fluentem quantitatem inveniamus cujus fluxio eſt $\frac{1}{2}dv^2\dot{y}$.

Sit

Sit hæc Quantitas $\frac{1}{2} d v^2 y - r$.

Igitur $\frac{1}{2} d v^2 \dot{y} + 3 d v \dot{v} y - \dot{r} = \frac{1}{2} d v^2 \dot{y}$

Adeoque $\dot{r} = 3 d v \dot{v} y = \frac{1}{2} d d v \dot{x}$ Sit $r = \frac{1}{2} d d v x - s$.

Igitur $\frac{1}{2} d d v \dot{x} = \frac{1}{2} d d v \dot{x} + \frac{1}{2} d d x \dot{v} - \dot{s}$.

adeoque, $\dot{s} = \frac{1}{2} d d v \dot{x} = \frac{3 d^3 x \dot{x}}{4\sqrt{dx - xx}} = \frac{3}{4} d^3 \dot{v} - \frac{3}{4} d^3 \dot{y}$,

per 2^um^ Theorema.

Igitur $s = \frac{3}{4} d \ v - \frac{3}{4} d^3 y$. adeoque area quæſita $= v^3 x - \frac{1}{2}$ $\frac{1}{2} d v^3 + \frac{3}{2} d v^2 y - \frac{3}{2} d d v x + \frac{3}{4} d^3 v. - \frac{3}{4} d^3 y$.

Quoniam autem Solida ex Ratione Curvarum genita, Superficies ab eadem Rotatione genitæ, Longitudines Curvarum, & Centra Gravitatis horum omnium a Quadratura Curvarum pendent, hæc ſi a Curvis ſupradictis pendent facillime computantur.

Poſtquam Theoremata hæc concinnaveram, eaque clariſſimo *Newtono*, ut ſupremo harum rerum Judici, monſtraveram; obtulit ille mihi Chartas ſuas manuſcriptas, quibus mihi conſtat ſe diu compotem fuiſſe methodi qua Æquatione Trinomiali quavis data naturam Curvæ exprimente, illa Curva aut quadratur aut ad ſimpliciorem Curvam reducitur.

Of finding the Root of an infinite Equation. Vid. *ſup.* Vol. 1. C. 1. §. xxii.

Nullus dubito Doctiſſimos Viros quorum ſcripta in *Actis Eruditorum* alibique tam valde Mathematicas diſciplinas promoverunt, Methodos huic noſtræ affines habere; adeoque nihil in his mihi aſcribendum puto niſi quod Theoremata hæc reperierim, neſcius an ullibi extarent; eaque ad formam tam facilem reduxerim, ut calculus omnis ad hanc materiam ſpectans uno quaſi intuitu conficiatur. Priuſquam ſcribendi finem facio, non abs re futurum eſſe arbitror, ſi nunc, nulla data citius occaſione, pauca quædam repoſuerim clariſſimi *Leibnitii*, animadverſionibus, ad Seriem quandam a me publicatam de radice infinitæ Æquationis invenienda. Exiſtimat Vir Clar. Seriem illam non ſatis generalem eſſe, utpote non attingentem caſus ubi Quantitates z & y in ſe invicem ducuntur; adeoque Seriem aliam pro meâ, ſubſtituit, hancque aſſerit mea infinite generaliorem: Illum autem in levem hunc errorem inductum eſſe ſuſpicor, quod quantitates a, b, c, d, &c. pro quantitatibus datis aſſumpſerit, cum pro quantitatibus datis aut indeterminatis indiſcriminatim uſurpandæ fuerint. Sed Exemplum unum afferre libet, quo pateat Seriem noſtram caſus omnes pervadere; ſit Æquatio $nyz - z^3 = y^3$. In Theoremate noſtro fiat $a = ny$, $b = o$, $c = -1$, $g = o$, $h = o$, $i = 1$, aut melius fiat $g = yy$, $b = o$, $i = o$,

in utroque Caſu fiet $Z = Z = \frac{yy}{n} + \frac{y^5}{n^4} + \frac{3y^8}{n^7} + \frac{12y^{11}}{n^{10}}$, &c.

The Quadrature of a Curve of the third Order, communicated *by Mr.* Abr. de Moivre, n. 345. p. 329.

V. I have looked a little farther into that Curve which fell lately under my Conſideration. It is not the *Foliate* as I did at firſt imagine, but I believe it ought not to make a *Species* diſtinct from it. AEB is the Curve I thus deſcribe. Let AB and BK be perpendicular to each other. From the Point A draw AR cutting BK in R, and make $RE=BR$, the Point E belongs to the Curve. Draw BC making an Angle of 45 *grad.* with AB, this Line BC touches the Curve in B; from the Point E draw ED perpendicular to BC, and calling BD, x; DE, y; AB, a; and making $\sqrt{8aa}=n$, the Equation belonging to that Curve, is $x^3+xxy+xyy+y^3=nxy$ or $\frac{x^4-y^4}{x-y}=nxy$. Taking $BG=AB$, and drawing GP perpendicular to BG, PG is an *Aſymptote.* In the *Foliate* the Equation is $x^3+y^3=\frac{1}{2}nxy$, in which the two Terms $xxy+xyy$ of the former Equation are wanting; and its *Aſymptote* is diſtant from B by $\frac{1}{3}BA$. Again draw EF perpendicular to AB: let BF be called z and FE, v; the Equation belonging to the Curve AEB is $vv=\frac{azz-z^3}{a+z}$. In the Foliate the Equation is $vv=\frac{azz-z^3}{a+3z}$. From theſe two laſt Equations, it ſeems that theſe Curves differ no more from one another than the *Circle* from the *Ellipſis.*

Fig. 10.

The Quadrature of the Curve here deſcribed has ſomething of Simplicity, with which I was well pleaſed. With the Radius BA and Center B deſcribe a Circle AKG, let the Square $HPST$ circumſcribe it, ſo that HP be parallel to AG; prolong FE till it meet the Circumference of the Circle in M, and through M draw LMQ parallel to HP. The Area BFE is equal to the Area $KHLM$, comprehended by KH, HL, LM and the Arc KM. And the Area Bfe is equal to the Area $KmLH$ or $KMPQ$. Therefore if BF and Bf are equal, the two Areas BFE, Bfe taken together are equal to the Rectangle HQ, and therefore the whole Space comprehended by $BEAXBe\Upsilon GZ$ (ſuppoſing Υ and Z to be at an infinite Diſtance) is equal to the circumſcribed Square HS.

N. B. *This Quadrature is eaſily demonſtrated from the Equation: for by it* a+z : a—z :: zz : vv, *that is,* AF : EF :: MF : FB, *and ſo* φF *the* Fluxion *of* AF *to* Ll *the* Fluxion *of* MF. *Hence the* Areola $EF\varphi e$ *will be always equal to the* Areala MLlμ, *and therefore the* Area AEF *always equal to the* Area MAL.

Hence it appears that this Curve requires the Quadrature of the Circle to ſquare it; whereas the Foliate *is exactly quadrable, the whole* Leaf *thereof being but one third of the Square of* A B, *which in this is above three Sevenths of the ſame. Again in our Curve, the greateſt Breadth is when the Point* F *divides the Line* A B *in extreme and mean Proportion: Whereas in the* Foliate *it is when* A B *is triple in Power to* B F. *And the greateſt* E F *or ordinate in the* Foliate, *is to that of our Curve nearly as* 3 *to* 4, *or exactly*

as $\sqrt{\frac{2}{3}\sqrt{\frac{1}{3}}-\frac{1}{3}}$ to $\sqrt{5\sqrt{\frac{5}{4}}-5\frac{1}{2}}$.

But ſtill theſe Differences are not enough to make them two diſtinct Species, *they being both defined by a like Equation, if the* Aſymptote S G P *be taken for the Diameter. And they are both comprehended under the* fortieth Kind *of the* Curves *of the* third Order, *as they ſtand enumerated by Sir* Iſaac Newton, *in his incomparable Treatiſe on that Subject.*

A general Method to determine the Quadratures *of Figures by Mr.* J. Craig. n. 284. p. 1346.

VI. Mihi non parum arridet, quod Methodus, quâ uſus ſum in determinandis Figurarum Quadraturis, tantopere a D. *Leibnitio*, & D. *Cheynæo* probata fuerit; ut ille alteri cuidam à ſe inventæ nonnihil ſimilem agnoſceret: D. *Chenæus* vero conjecturam fecerit ei non multo abſimilem eſſe illam quâ utitur D. *Newtonus*; eundemque ipſe tanto cum ſucceſſu ſecutus eſt, ut Methodus calculi differentialis inverſa incredibili incremento ab illo promota ſit in Libro, quem D. *Archibaldo Pitcarnio* Patriæ noſtræ & ſeculi hujus ornamento, inſcripſit. Sed multa ad Methodum illam inverſam perficiendam neceſſaria adhuc invenienda ſuperſunt. Ego jam rationes aliquot breviter exponam, quæ faciunt ut reliqua per methodos hactenus uſurpatas non poſſe obtineri putem.

Et primo quidem, cum ex datâ relatione inter z & y quæritur s: z *d* y, omnes illæ Methodi poſtulant ut z per y & datas exprimatur; quod tamen fieri non poteſt, quando æquatio relationem illam definiens ultra Cubicam vel Biquadraticam aſcendit. Nam, non ſine magno hujus ſcientiæ opprobrio, hæret hîc adhuc Algebra vulgaris. Secundo quamvis Regula innoteſceret generalis inveniendi Radices æquationum cujuſcunque gradus; huic tamen Methodo inverſæ prorſus foret inutilis: Radix enim z ſurdis tam complicatis involveretur, ut nullâ arte (hactenus cognitâ) a differentiali ad Integralem regreſſus dari poſſet. Ob has rationes, alias vias & conatu non prorſus irrito rem ſum aggreſſus, eorumque Specimen publico impertiri conſtitui.

Sectio 1.] Sit $z^m + a y^n = b z^r y^e$ æquatio exprimens relationem inter Ordinatam z & abciſſam y, in quâ Exponentes m, n, e, r, denotant quoſlibet Numeros, Integros vel Fractos, Affirmativos vel Negativos. Ponatur $r - n = c$ Erit.

AREA

$$AREA = \frac{m}{m+n} zy + \frac{mc+ne}{mm+nc+1+nm+ne+1} + \frac{b}{a} z^{e+1} y^{c+1} +$$

$$\frac{m-e\times c+1+r\times e+1}{m\times 2c+1+n\times 2e+1} + \frac{bB}{a} z^{2e+1} y^{2c+1} +$$

$$\frac{m-e\times 2c+1+r\times 2e+1}{m\times 3c+1+n\times 3e+1} + \frac{bC}{a} z^{3e+1} y^{3c+1} +$$

$$\frac{m-e\times 3c+1+r\times 3e+1}{m\times 4c+1+n\times 4e+1} + \frac{bD}{a} z^{4e+1} y^{4c+1} +$$

$$\frac{m-e\times 4c+1+r\times 4e+1}{m\times 5c+1+n\times 5e+1} + \frac{bE}{a} z^{5e+1} y^{5c+1} + \&c.$$

De hâc Serie hæc ſunt notanda: (1.) Quòd literæ majuſculæ *B*, *C*, *D*, &c. deſignent coefficientes terminorum ipſis immediatè præcedentium: (2.) Quòd exhibeat Quadraturas omnium Figurarum Quadrabilium, quarum Curvæ per æquationem trium terminorum definiuntur: (3.) Et quòd ſemper ſint Quadrabiles, quando $\frac{m\times r-r}{mn-rm-en}$ eſt numerus integer & affirmativus, quem vocemus *l*. (4.) Speciatim $l+1$ dat numerum Terminorum (ab initio ſumptorum) Seriei Aream quæſitam conſtituentium: (5.) Quòd ſi ponatur $e=o$, mutabitur hæc Series in Celebre Theorema *Newtonianum* pro Binomio communi; & proinde hoc Theorema eſt hujus Seriei caſus ſpecialis & ſimplex: (6.) Cùm ſit Applica-

tio hujus Seriei ad Figuram particularem, hæ regulæ ſunt obſervandæ. 1ª Reducatur Æquatio Curvam datam definiens, ad formam generalem, & ex Comparatione particularis cum generali invenientur coefficientes a, b; ut & exponentes m, n, e, r. Secunda, Si exponentes ſic determinati non faciant l numerum integrum & affirmativum, (juxta conditionem in Not. 3. aſſignatam) tum alius terminus Æquationis particularis a Quantitate z liberetur; & ſi nunc exponentibus denuo determinatis non competat illa Quadrabilitatis conditio; tum reliquus terminus a Quantitate z liberetur: Nam nullo Labore quilibet ex tribus terminis Æquationem datam conſtituentibus a Quantitate z liberari poteſt. Tertia, Si Æquationi per Regulam præcedentem tractatæ non conveniat prædicta Quadrabilitatis Conditio; tum per Seriem quæratur Areæ Complementum $\int : y\,dz$: quo cognito ſtatim habetur Area quæſita; nam, ut omnibus notum, $zy, -\int : y\,dz = \int : z\,dy$. Et ut ſine confuſione Complementum per Seriem obtineatur; in Æquatione data Curvam particularem definiente pro z ſcribatur Y, & pro y ſcribatur Z: Factâque hâc mutatione Ordinatæ in Abſciſſam, & Abſciſſæ in Ordinatam tractetur æquatio juxta præcepta Regulæ ſecundæ; donec illi conveniat Quadrabilitatis Conditio, vel eandem ipſi non poſſe convenire pateat.

Exemplum 1.] Sit $z^3 + y^3 = bzy$. Quia hîc $m = 3$, $n = 3$, $e = 1$, $r = 1$, $a = 1$; ideo $l = 1$, adeoque $l + 1 = 2$. Et proinde (juxta Not. 4.) duo primi Seriei termini dant Aream $= \frac{1}{2} zy - \frac{1}{6} bz^2 y^{-1}$.

Exemplum 2.] Sit $z^7 + ay^3 = bzy^3$, ubi $m = 7$, $n = 3$, $e = 1$, $r = 2$; qui faciunt $l = 2$; ideo (juxta Not. 4.) tres primi Seriei termini dabunt quæſitam.

$$\text{AREAM} = \frac{7}{10} zy - \frac{b}{15a} z^2 - \frac{2b^2}{15a^2} z^3 y^{-1}.$$

Exemp. 3.] Sit $z^3 + ky^5 = hz^{-2} y^{11}$; ubi $m = r$, $n = 5$, $e = 2$, $r = 11$; at quia hi non faciunt l numerum integrum & affirmativum; ideo (per Regulam ſecundam) libero terminum $hz^{-2} y^{11}$, a quantitate z; & ſic Æquatio fit $z^5 - hy^{11} = -kz^2 y^5$; ubi $a = -h$, $b = -k$; & $m = 5$, $n = 11$ $e = 2$, $r = e$; qui faciunt $l = 1$: unde

$$\text{AREA} = \frac{5}{16} zy - \frac{5}{16h} z^3 y^{-5}$$

Exemp. 4.] Sit $z^2 - hy^2 = -kz^2 y^2$; ubi $m = 2$, $n = 2$, $e = 2$, $r = 2$; qui non faciunt l numerum integrum & affirmativum; ideo libero terminum $-kz^2 y^2$ a quantitate z; & tum $z^0 + ky^2 = hz^{-2} y^2$ ubi $a = k$, $b = h$; & $m = 0$, $n = 2$, $e = -2$, qui faciunt $l = 1$, ideo

AREA

$$\text{AREA} = \frac{h}{k} z^{-1} y$$

Exemp. 5. Sit $z^2 - \frac{4g^2}{h} y^6 = -\frac{g}{h} z^2 y^4$; ubi $m = 2$, $n = 6$, $e =$ 2, $r = 4$; qui non faciunt l numerum integrum & affirmativum; idemque contingit liberato (à quantitate z) utrolibet ex reliquis: Ideo juxta regulam tertiam quæro Complementum; quare (ut jam præmonui) pono $z = Y$, $y = Z$; unde æquatio data erit

$$Y^2 - \frac{4g^2}{h} Z^6 = -\frac{g}{h} Z^4 Y^2;$$

quæ (juxta Reg. 1.) reducta ad formam generalem erit hujus modi

$$Z^6 - \frac{h}{4g^2} Y^2 = -\frac{1}{4g} Z^4 Y^2 \text{ ubi } m = 6, n = 2, e = 4,$$

$r = 2$; qui non faciunt l numerum integrum & affirmativum; ideo (juxta Reg. 2.) libero terminum ultimum *a* Z, unde

$$Z^2 - \frac{l}{4g} Y^2 = -\frac{h}{4g^2} Z^{-4} Y^2; \text{ ubi } m = 2, n = 2, e = -4,$$

$r = 2$; unde $l = 1$; & $a = -\frac{1}{4g}$, $b = \frac{h}{4g^2}$; Unde Areæ quæsitæ complementum est

$$= \tfrac{1}{2} ZY - \frac{h}{2g} Z^{-3} Y \text{ seu } \tfrac{1}{2} zy - \frac{h}{2g} zy^{-3};$$

Ergo etiam Area quæsita $\int z\,dy = \tfrac{1}{2} zy + \frac{h}{2g} zy^{-3}$

Sectio 2.] Sit $z^m + ay^n - bz^{2e} y^{2c+n} + fz^e y^{c+n}$ æquatio exprimens Relationem inter ordinatam z & Abscissam y. Erit

AREA

$$\text{AREA} = Azy + Bz^{e+1}y^{c+1} + Cz^{2e+1}y^{2c+1} + Dz^{3e+1}y^{3c+1} + Ez^{4e+1}y^{4c+1} + Fz^{5e+1}y^{5c+1}, \&c.$$

Ubi (positis $2c + n = r$, $c + n = s$) $A = \frac{n}{m+n}$;

$$B = \frac{m - e + s \times A + e - m}{m \times c + 1 + n \times e + 1} \times \frac{f}{a}$$

$$C = \frac{m - 2e + r \times bA + m - e \times c + 1 + r \times e + 1 \times fB + 2eb - mb}{ma \times 2c + 1 + na \times 2e + 1}$$

$$D = \frac{m - 2e \times c + 1 + r \times e + 1 \times bB + m - e \times 2c + 1 + s \times 2e + 1 \times fC}{ma \times 3c + 1 + na \times 3e + 1}$$

$$E = \frac{m - 2e \times 2c + 1 + r \times 2e + 1 \times bC + m - e \times 3c + 1 + s \times 3e + 1 \times fD}{ma \times 4c + 1 + na \times 4e + 1}$$

$$F = \frac{m - 2e \times 3c + 1 + r \times 3e + 1 \times bD + m - e \times 4c + 1 + s \times 4e + 1 \times fF}{ma \times 5c + 1 + na \times 5e + 1}$$

De hac Serie (cujus progreſſio primo ferè intuitu eſt manifeſta) hæc ſunt notanda. (1.) Quod Figuræ (quarum Curvæ prædicta Æquatione definiuntur) ſunt Quadrabiles, quando Numeri exponentiales m, n, e, c;

& coefficientes a, b, f habent relationes modo assignandas; scil. quando $\frac{2c+m\times n-2e}{-cm-en}$ est numerus integer & affirmativus, quem vocemus l. & (cum l est major quam 2) quando Coefficientium relatio est hæc.

$$\frac{m-2e\times lc-c+1+r\times le-e+1}{e-m\times lc+1-s\times le+1}\times\frac{bU}{f}=$$

$$\frac{m-2e\times lc-2c+1+r\times le-2e+1}{m\times lc+1+n\times le+1}\times\frac{bP}{a}+$$

$$\frac{m-e\times lc-c+1+r\times le-e+1}{m\times lc+1+n\times le+1}\times\frac{fU}{a}$$

Ubi U & P denotant Coefficientes Terminorum duorum, qui immediate præcedunt ultimo Areæ quæsitæ Termino; scil. U est coefficiens termini ad Ultimum proprioris, P coefficiens termini ab ultimo remotioris: ut si $Fz^{5e+1}y^{5c+1}$ esset ultimus Areæ quæsitæ terminus, tum U denotaret E, & P denotaret D. (2) Ultimus ille Areæ quæsitæ terminus ex valore numeri l cognoscitur; nam hic etiam $l+1$ dat numerum terminorum (ab initio sumptorum) Seriei, qui Aream quæsitam constituunt. (3) Si fuerit $l=1$, tum coefficientium relatio debet esse hæc

$$\frac{2e-m\times 1-A+rAb}{e-m\times c+1-s\times e+1}\times\frac{f}{f}=\frac{e-m\times 1-A+sA}{m\times c+1+n\times e+1}\times\frac{f}{a};$$

Si $l=2$; relatio debet esse hæc

$m-$

$$\frac{m-2e\times c+1+r\times e+1}{e-m\times 2c+1+s\times 2e+1}\times\frac{bB}{f}=$$

$$\frac{2e-m\times 1-A+rA}{m\times 2c+1+n\times 2e+1}\times\frac{b}{a}+$$

$$\frac{m-e\times c+1+s\times e+1}{m\times 2c+1+n\times 2e+1}\times\frac{fB}{a}$$

Sectio 3.] Sit $z=ay+bz^{\frac{m}{y}}+fz^{\frac{n}{y}}+gz^{\frac{e}{y}}+hz^{\frac{c+n}{y}}+fz^{\frac{2e}{y}}+hz^{\frac{2c+n}{y}}+gz^{\frac{3e}{y}}+hz^{\frac{3c+n}{y}}+hz^{\frac{4e}{y}}+hz^{\frac{4c+n}{y}}+$ &c. æquatio exprimens relationem inter ordinatam z & abſciſſam y; & conſtans terminis quotcunque erit.

$$\text{Area}=Azy+Bz^{\frac{e+1}{y}}+Cz^{\frac{c+1}{y}}+Dz^{\frac{2e+1}{y}}+Ez^{\frac{2c+1}{y}}+Fz^{\frac{3e+1}{y}}+Gz^{\frac{3c+1}{y}}+Hz^{\frac{4e+1}{y}}+Iz^{\frac{4c+1}{y}}+\text{&c.}$$

Quod ni fallor, eſt Theorema non contemnendum, Calculo per-facili inveniuntur A, B, C, D, E, &c. ut & Quadrabilitatis conditiones, & quot termini ſeriei Aream quæſitam conſtituant. Creſcit quidem numerus harum conditionum pro multitudine terminorum, ex quibus conſtat æquatio relationem inter z & y definiens. Et ſpeciatim ſi illa terminorum multitudo vocetur N; tum $N-2$ eſt numerus conditionum Quadrabilitatis; quarum una Exponentium m, n, e, c relationem reſpicit, eſtque hæc; ut

$$\frac{Nc-2c+2e-Ne+m+n}{-cm-en},$$

eſt numerus (quem vocemus l) integer & affirmativus. Reliquæ vero conditiones coefficientium a, b, f, g, h, &c. reſpiciunt. Ac denique $l+1$ dat numerum terminorum (ab initio ſumptorum) ſeriei, qui Aream quæſitam conſtituunt.

Coroll.

Coroll. Ex hac Serie generali deduci poteſt Series, quæ exhibeat Quaduraturas Figurarum, quarum Curvæ definiuntur per æquationem conſtantem terminis quibuſvis, qui æquationem Sectionis tertiæ generalem conſtituunt. Nam ad hanc obtinendam opus tantum eſt Seriem computare pro æquatione conſtante tot terminis (ab initio ſumptis) æquationis generalis, quot includent Terminos æquatio Curvas definiens. Tum ex valoribus quantitatum *A*, *B*, *C*, *D*, &c. Eliminentur illæ coefficientes *b*, *f*, *g*, &c. quæ ad æquationem propoſitam non ſpectant; reliquæ dabunt aream quæſitam. Exemplo res patebit.

Sectio 4.] Sit $z^{m} = ay^{n} + bz^{e}y^{c+n} + gz^{3e}y^{3c+n}$

Æquatio exprimens relationem inter *Z* & *Y*. Jam quia

$$z^{m} = ay^{n} + bz^{e}y^{c+n} + fz^{2e}y^{2c+n} + gz^{3e}y^{3c+n}$$

eſt illa pars æquationis quæ (ſumptis terminis in ordine a principio) includit æquationem datam; quam deinceps (brevitatis cauſa) æquationem completam vocabo; ideo Figurarum (quarum Curvæ definiuntur per æquationem completam.)

$$\text{Areæ} = Azy + Bz^{e+1}y^{c+1} + Cz^{2e+1}y^{2c+1} + Dz^{3e+1}y^{3c+1} + Ez^{4e+1}y^{4c+1} + Fz^{5e+1}y^{5c+1} + \&c.$$

& *a*, *b*, *fg* ingredientur valores quantitatum *B*, *C*, *D*, *E*, *F*, &c. Si ergo in his valoribus ponatur ubique $f = o$ (quia $fz^{2e}y^{2c+n}$ æquationem datam non ingreditur) habebis valores quantitatum *A*, *B*, *C*, *D*, *E*, &c. qui in Serie ſubſtituti dabunt Areas quæſitas. Et Calculo inito inveni

$$A = \frac{m}{m+n}. \qquad B = \frac{c - \overline{m - c - n \times A} + m - e}{m \times c+1 + n \times e-1} \times \frac{b}{a}$$

$$C = \frac{c + n \times e+1 + m - e \times c+1}{m \times 2c+1 + n \times 2e+1} \times \frac{bB}{a}$$

$$D = \frac{m - 3e \times 1 - A + 3c - n \times - A \times g}{ma \times 3c + 1} \Big| \frac{+ m - e \times 2c + 1 + c + n \times 2e + 1 \times - bC}{+ na \times 3e + 1}$$

$$E = \frac{m - 3e \times c + 1 + 3c + n \times e + 1 \times}{ma \times 4c + 1} \Big| \frac{- gB + m - e \times 3c + 1 + c + n \times 3e + 1 \times - bD}{+ na \times 4e + 1}$$

$$F = \frac{m - 3e \times 2c + 1 + 3c + n \times 2e + 1 \times}{+ ma \times 5c + 1} \Big| \frac{- gC + m - e \times 4c + 1 + c + n \times 4e + 1 \times - bE}{+ na \times 5e + 1}$$

$$G = \frac{m - 3e \times 3c + 1\ 3 + c + n \times 3e + 1 \times}{+ ma \times 6c + 1} \Big| \frac{- gD + m - e \times 5c + 1 + c + n \times 5e + 1 \times - bF}{+ na \times 6e + 1}$$

Ex

Ex his patet progreſſio reliquorum in infinitum. Et ſic habetur Series exhibens Quadraturas omnium Figurarum, quarum Curvæ definiuntur per hanc æquationem quatuor terminorum

$$z = ay^{\frac{m}{n}} + bz^{\frac{e}{c+n}} y^{\frac{3e}{3c+n}} + gz^{\frac{e}{c+n}} y^{\frac{3e}{3c+n}}.$$

Et notandum quod conditiones Quadrabilitatis & numerus terminorum Seriei, Aream quamlibet quæſitam conſtituentium, eadem ſunt cum conditionibus Quadrabilitatis, & numero Terminorum, quæ conveniunt Figuris, quarum Curvæ per æquationes completas definiuntur.

Coroll. Præter has duas ſeries in § 2 & 4 propter Figuras quatuor terminorum, poſſunt eodem modo infinitæ aliæ ſeries computari pro cæteris caſibus Figurarum, quatuor terminorum. Quod etiam intelligendum eſt de omnibus aliis Figuris, quarum Curvæ per æquationes quotlibet terminorum numero conſtantes definiuntur.

Non jam vacat ipſam Methodum minutiatim deſcribere, per quam ad hujuſmodi Series pervenio; brevem tamen ejus rationem exponere forte non ingratum erit. Aſſumo Seriem ex z pariter ac y compoſitam, ſcil. $Azy^{\frac{p}{q}} + Bz^{\frac{s}{h}} y^{\frac{l}{k}} + Cz\, y + Dz\, y + \&c. = \int : z\, dy$. Cujus ſinguli termini (præter primum) habeant Exponentes incognitos. Tum æquationem inſtituo inter duos valores quantitatis dz, quorum alter ex hac ſerie, alter ex æquatione relationem inter z & y definiente per Methodum Calculi Differentialis directam facile invenitur. Ex terminis hujus æquationis ritè reductæ primo determino exponentes incognitos p, q, g, h, l, k, &c. Et deinde coefficientes A, B, C, &c. Et ſi plures ſint comparationes, quam quæ determinandis his coefficientibus ſufficiunt, tum ex reliquis deduco Quadrabilitatis conditiones. Si recta ineatur via, Calculus eſt longe facillimus; multaſque habeo Regulas huc ſpectantes quas alias forſan tradam; ut & uſum hujus Methodi in inveniendis Quadraturis irrationalibus finitis, quando rationales non dantur: res enim omnino in poteſtate eſt.

VII. *Solutio Problematis a Cl. D.* Jo. Bernoulli *in* Diario *Gallico*, Feb. 1703. *propoſiti.*

Problema.] Propoſitæ Curvæ Geometricæ alias innumeras Longitudine Æquales invenire.

To find other *Curves equal in Length to any given* Geometrical *Curve, by Mr.* J. Craig, n. 289. p. 1527.

Solutio. Sint w, s, co-ordinatæ Curvæ datæ; Curvæ quæſitæ ſint co-ordinatæ x, y: tum ex conditione Problematis erit $dw^2 + ds^2 = dx^2 + dy^2$ Ponatur $dx = dw - m\,dz$, unde erit $dy = \sqrt{ds^2 + 2m\,dw\,dz - m^2 dz^2}$; in hac pro ds ſubſtituatur ejus Valor per w, dw, & determinatas expreſſus: & pro dz aſſumatur talis valor ex w, dw & determinatis compoſitus,

poſitus, ut Valores Quantitatum dx, dy, ſint ſummabiles: Et ſic habentur x ac y Co-ordinatæ Curvæ quæſitæ. *Q. E. I.*

Exemplum 1. Invenire Curvam æqualem Lineæ Parabolicæ. Sit $2a$ latus rectum Parabolæ; adeoq; $2asds = w^2$ unde $ds^2 = a^2 w^2 dw^2$ adeoque $dy = \sqrt{a^2 w^2 dw^2 + 2mdwdz - m^2 dz^2}$; ut hæc ſit ſummabilis aſſumatur $mdz = \frac{w^2 dw}{a^2}$: unde $dx = dw - \frac{w^2 dw}{a^2}$: $dy = dw\sqrt{3a^2 w^2 - a^4 w^4}$ quarum integrales per Methodos dudùm cognitas invenientur $x = w\frac{w^3}{3a^2}$ $y = \frac{w^2 - 3a^2}{3a^2}\sqrt{3a^2 - w^2}$.

Exemplum 2. Invenire Curvam æqualem Circulari. Sit a Radius Circuli; tum $s = \sqrt{a^2 - w^2}$; unde $ds^2 = \frac{w^2 dw^2}{a^2 - w^2}$, & proinde erit $dy = \sqrt{\frac{w^2 dw^2}{a - w^2} + 2mdwdz - m^2 dz^2}$; ut hæc ſit ſummabilis aſſumatur $mdz = \frac{4w^2 dw}{a^2}$ adeoque $dx = dw - \frac{4w^2 dw}{a^2}$: $dy = \frac{-3a^2 w + 4w^3}{a^2\sqrt{a^2 - w^2}}dw$. Quarum Integrales per communes Methodos inveniuntur $x = w - \frac{4w^3}{3a^2}$, $y = \frac{a^2 - 4w^2}{3a^2}$, $\sqrt{a^2 w^2}$:

Exemp. 3. Invenire Curvam æqualem Ellipticæ. Sit $2r$ latus rectum, $2a$ latus tranſverſum, tum $s = \frac{r\sqrt{a^2 - w^2}}{a}$ unde erit $ds^2 = \frac{r^2 w^2 dw^2}{a^4 a^2 w^2}$, adeoque $dy = \sqrt{\frac{r^2 w^2 dw^2}{a^4 - a^2 w^2} + 2m\,dw\,dz - m^2 dz^2}$; ut hæc ſit ſummabilis aſſumatur $mdz = \frac{2a + 2r}{a^3} w^2 dw$:

unde

unde $dx = d\ w \frac{-2a-2r}{a^3} w^2\ dw.$ $dy = dw \sqrt{\frac{r^2\ w^2}{a^4 - a^2 w^2} + \frac{4a+4r}{a^3} w^2 + \frac{2a+2r}{-a^6} w^4}$; quarum Integrales per Methodos notiſſimas inveniuntur $x = w \frac{-2a-2r}{3a^3} w^3$. $y = \frac{2a^3 - ra^2 - 2aw^2 - 2rw^2}{3a^3} \sqrt{a^2 - w^2}$.

Exemp. 4.] Invenire Curvam æqualem Parabolæ Cubicali cujus Æquatio ſit $3a^2 s = w^3$. Unde $ds^2 = \frac{w^4\ dw^2}{a^2}$ & proinde $dy = \sqrt{a^4 w^4\ dw^2 + 2m\ dw\ dz - m^2 dz^2}$; Ut hæc ſit ſummabilis aſſumatur $m\ dz = \frac{w^2\ dw}{2a^2}$. Unde $dx = dw - \frac{w^2}{2a^2} dw \sqrt{3w^2 + 4a^2}$. Quarum Integrales per Methodos vulgo notas ſunt $x = w - \frac{w^3}{6a^2}$, $y = \frac{2}{9} + \sqrt{3w^2 + 4a^2}$.

Ex aliis infinitis Valoribus Quantitatis $m\ dz$ debitè aſſumptis infinitæ Curvæ poſſunt inveniri datæ æquales. Obſervandum eſt hoc Problema aliquam habere cum Problemate quodam *Diophantæo* affinitatem: Problema *Diophanti* eſt, dividere ſummam duorum Quadratorum in duo alia quadrata, quorum latera ſint rationalia; & Problema *Bernouilli* eſt, dividere ſummam duorum Quadratorum in duo alia quadrata, quorum latera ſunt ſummabilia. Sicut Problematis *Diophantæi* ſolutio a vulgari tantùm Algebrâ dependet, ſic *Bernoulliani* Problematis ſolutio communes tantum Fluxionum Methodos inverſas requirit: utriuſque artificium in debitâ laterum quæſitorum aſſumptione conſiſtit; ſcil. *Diophantæum* ut ſint rationalia, *Bernoullianum* ut ſint ſummabilia.

VIII. The *Circle*, *Ellipſis* and *Hyperbola* being not geometrically quadrable (as infinite others) there have been two Ways made uſe of to find their *Area's*. By *Converging Series*, whereby Approaches are made nearer and nearer, according to the Exactneſs deſired. 2. By *Quadratrices*, that is, mechanical Curves, which determine the Length of

A new Quadratrix to the Hyperbola *by Mr.* Perks, n. 306. p. 2253.

of certain Lines, whoſe Squares or Rectangles give the *Area* of the Figure deſired. Of this Sort is the old *Quadratrix* of *Dinoſtratus*, by which the Circle and Ellipſe are ſquared; and another Sort (for the ſame Purpoſe) I inſerted in the *Tranſactions* about five Years ago. Since that, having found the Conſtruction of a Curve, from whence (beſides its own *Quadrature* and *Rectification*) the *Quadrature* of the *Hyperbola* is derived, I thought the following Account might not (to ſome) be unacceptable.

Vid. ſupra, V. 1. C. 1. S. VII.

Fig. 11. Let AB, CD, be two ſtrait Rulars joined at B, and there making a right Angle. (Their Length according to the Largeneſs of the Figure you will deſcribe.) EF is another Rular ſomewhat longer than AB. Near the one End E, let a little *Truckle-wheel* (repreſented edge-wiſe by gh, and made of a thin Plate of Braſs or Iron) be faſtened to the Rular by a Pin (i,) through its Center, ſo that the Wheel may turn about upon the Pin (i) tight to the Rular without joggling.

On the under Side of this Rular (the Side from the Eye in the Scheme) let there be pinn'd or glewed a little Piece of Wood (in the Form of a Quadrant, the Part which is ſeen being marked kl) whoſe Edge (or Limb) kl, is an Arch of a Circle of Center (i,) and *Radius* ib (the ſame with the little Wheel.) The Deſign of this Piece of Wood is, that in the ſeveral Poſitions of the Rular EF, the circular Limb kl always touching and ſliding by the Edge of the Rular AB, the Center of the Wheel may be always in a Line (im) parallel to the Rular AB.

In the Rular CD make $MB = ih$ or ik, and at M faſten a little Pin, and another to the Rular EF near the Wheel, as at P. To theſe two Ends let be faſtened the two Ends of a String MR, ſo that its whole Length (from Pin to Pin) $+ Pi$, be equal to the intended Axis of the Curve TW.

The Inſtrument being thus prepar'd, let a ſtrong Rular SO, be faſtened (or held faſt) upon the Paper or Plane that the Curve is to be drawn upon. Lay the Rular EF from M towards A, and parallel to AB, ſo that the String lie all ſtrait along the Edge of the Rular EF from M to p, the Point Sk of the Quadrantal Piece of Wood reſting upon the Edge of the Rular AB. Then with a ſmall Pin at M keeping the String cloſe to the Edge of the Rular EF, and with your other Hand upon the End E, keeping the Wheel tight to the Paper or Plane, move the Pin, String and Rular EF from M towards O, the Rular CD, ſliding along by the faſtened Rular SO in a right Line, the Wheel gh will by its Motion deſcribe the deſigned Curve TV.

Note, The Semidiameter of the little Wheel muſt be about the *Sum* of the Thickneſſes of the two Rulars EF and AB, that it may touch the Paper. Alſo it will be convenient that its Edge be thin, and a little rough, that it may not ſlide flat-ways, and that it may leave a viſible Impreſſion.

From this Conſtruction the following Properties are demonſtrable:

1. It is evident from the Conſtruction, that the *Sum of the Tangent and Subtangent* is every where equal to the ſame given Line ($= MR + Ri = TW$,) for the String (firſt ſtrait at TW, afterwards making an Angle at R) being every where the ſame, the Line Ri (or $RP + Pi$) is always the Tangent, and the Remainder RM the Subtangent; the Contact of the Wheel with the Plane, being the Point of the Curve to which they belong.

2. It hence follows, that any aſſignable Part of the Curve is *rectifiable*, or equal to any aſſignable ſtrait Line. In *Fig.* 12. Let FAE be a Part of the Curve, its Vertex F. HDd is the Line deſcribed by the Motion of the Pin R (in *Fig.* 11.) and may be ſhewn to be aſſymptote to the Curve. FH a Perpendicular to HD. Let A be the given Point in the Curve, AD the Tangent, and BD the Subtangent to the ſame Point A. Let a be another Point in the Curve infinitely near to A, to which let ad be the Tangent, and bd the Subtangent. Draw AG ag perpendicular to FH and AB, ab perpendicular to HD. By the Conſtruction $AD + DB = ad + db$. Let $a\delta$ be made equal to aD, and draw $D\delta$. Then becauſe $ad + bd = AD + DB$. Subtract bD and aD (or $a\delta$) from both Sums (Equals from Equals) there remains $\delta d + dD = Aa + Bb$ (or Ca). AaC, $Dd\delta$ are like Triangles (or differing infinitely little from ſuch) therefore Ca (Bb) : $Aa :: \delta d : Dd$. and compounding $Bb + Aa : Aa :: \delta d + Dd : Dd$. Alternating $Bb + Aa : \delta d + Dd :: Aa : Dd$. But $Bb + Aa = \delta d + Dd$ (as is ſhewn above) therefore $Aa = Dd$. Aa is the fluxional Particle of the Curve FA, and Dd is the fluxional Particle of the Line HD: Theſe Fluxions or Augments, being equal, and their flowing Quantities beginning together, are themſelves therefore equal, *viz.* $FA = HD$.

Let $FG = x$. $GA\ (= HB) = y$. $AD = t$. $BD = S$. So is the Curve $FA = HD = y + S$: that is, *the Curve from the Vertex to any given Point therein, is equal to the Sum of its Ordinate, and Subtangent to the ſame Point which is its ſecond Property.*

3. The next Property (and whereupon I call it the *Hyperbolic Quadratrix*) is this: Let FAE be a Part of the Curve, (*&c.* as before.) $FIKH$ is a Square upon the Line FH. ΛIL is an Equilater Hyperbola, whoſe Vertex is I, its Aſſymptotes HO, HR; its Axis $HI\mu$. From a given Point L in the Hyperbola (below its Vertex I) draw LA parallel to the Aſſymptote RH, interſecting the Diagonal IH in M, FH in G, and touching the Quadratrix in A. I ſay, that the Hyperbolic Area ILM is equal to a Rectangle, whoſe Sides are the *Ordinate* GA, and twice FH, the Axis to the Quadratrix, that is, Trilin. $ILM = 2\,FH \times GA$. Fig. 12.

Let

Let $FH=a$, $FG=x$, $GA=y$. Becauſe of the Hyperbola GLX $GH(LS)=FHq$, therefore $GL=\frac{FHq}{GH}$; and $LM=\frac{FHq}{GH}-GH$ (MG) that is, $LM=\frac{aa}{ax}-a+x=\frac{2ax-xx}{a-x}$, and conſequently the Fluxion of the Area $ILM=\frac{2ax-xx}{a\quad x}\dot{x}$

In the Rectangle Triangle ADB, $AB=a-x$, $BD=S$, $AD=t=a-S$; then is $ADq=ABq+BDq$: or $aa2aS+SS=aa-2ax+xx+SS$, which being thus reduced, gives

$$S=\frac{2ax-xx}{2a}$$

Let la be a right Line ſuppoſed infinitely near and parallel to LA, and interſecting AB in C. Becauſe of like Triangles ACa, ABD;

$AB:BD::AC:Ca$ that is $a-x:S\ (=\frac{2ax-xx}{2\quad a})::\dot{x}:\dot{y}$.

therefore $\dot{y}=\frac{2ax-xx}{2aa-2ax}\dot{x}$. Multiply each by $2a$, and 'tis $2a\dot{y}$ $\frac{2ax-xx}{a-x}\dot{x}$. The *flowing Quantity* of $2a\dot{y}$ is $2ay$, and the *flowing Quantity* of $\frac{2ax-xx}{a\quad x}x$ is the Hyperbolic Area ILM (as is ſhewn before.) Theſe two Area's beginning together at F and I, and having every where equal *Fluxions*, or Augments, are therefore themſelves every where equal.

N. The Quadrature of the Trilinear Figure ILM being thus found, any other Area bounded with the Curve-line IL, and any other Right Lines is alſo given.

4. Sup-

4. Suppoſing the ſame Things as in the precedent Propoſition, I ſay, that the Area of the Quadratrix $FabHF$ is equal to half the Square of Fg, wanting the Cube of Fg divided by $6\,FH$, or $FabHF = \frac{xx}{x} - \frac{xxx}{6a}$. The Fluxion of this Area is the Rectangle $CabB = \overline{a-x} \times \dot{y} = \overline{a-x} \times \frac{2ax-xx}{2aa-ax}\dot{x} = x\dot{x} - \frac{xx}{2a}\dot{x}$. The flowing Quantity of $x\,x$ is $\frac{1}{2}\,x\,x$: And the flowing Quantity of $-\frac{xx}{2a}\dot{x}$ is $-\frac{xxx}{6a}$ [as is eaſily ſhewn by bringing back theſe flowing Quantities to their reſpective Fluxions.] And hence alſo it follows, that the whole Area continued on infinitely towards E, is *one third of the Square* $FIKH$; or $\frac{1}{3}\,a\,a$. For ſuppoſing $x = a$ the Area above becomes $\frac{aa}{2} - \frac{aa}{6} - \frac{aa}{3}$.

While I was conſidering the other Properties of this Curve, and had given ſome Account of them to my Ingenious Friend Mr. *John Colſon*, he returned me a Letter with the Addition of the Quadrature of the Curves Area, which I had not then enquired into.

5. Suppoſing ſtill the ſame Things, I ſay that the Solid made by the Converſion of the Area $FabHF$ about the Line Hb as an Axis, is equal to a Cylinder whoſe Radius is $FH = a$, and Height equal to $\frac{xx}{2a} - \frac{x^3}{2aa} + \frac{x^4}{8a^3}$. And the whole Solid made by Converſion of the whole Figure infinitely continued, is equal to an eighth Part of a Cylinder, whoſe Radius and Height are each equal to FH or a.

Let $\frac{P}{D}$ expreſs the Proportion of the Periphery and Diameter of a

Then is $\frac{P}{D}\,ab$ quad. the Area of a Circle whoſe Radius is ab. And

becauſe $Ca = \dot{y} = \frac{x - \frac{xx}{2a}}{a - x}\,\dot{x}$ the Fluxion of the Solid is $\frac{P}{D}\,ab.$ q.

$\times \frac{x - \frac{xx}{2a}}{\dot{x}}$ or $\frac{P}{D}\,a - a^2 \times \frac{x - \frac{xx}{2a}}{a - x} = \frac{P}{D}\,\overline{ax - \frac{3}{2}xx + \frac{x^3}{2a}} \times \dot{x}$

whoſe flowing Quantity is $\frac{P}{D}\,axx - xxx + \frac{x^4}{8a}$. Which Solid

being divided by $\frac{P}{D}\,aa$ (the Area of a Circle whoſe Radius is a)

gives $\frac{xx}{2a} - \frac{xxx}{2aa} + \frac{x^4}{8aa}$ for the Height of a Cylinder on the ſaid

circular Baſe, and equal to the Solid made by Converſion of the Area $FabHF$ about the Line Hb as an Axis. When $x = a$ (that is, when the whole Figure is turn'd about its Aſymptote) the Height

$\frac{xx}{2a} - \frac{x^3}{2aa} + \frac{x^4}{8aa}$ become $\frac{1}{8}\,a.$

6. The Curve Surface of the Solid generated by the Converſion of the Figure $FabHF$ about HB, is equal to the Curve Surface of a

Cylinder whoſe Radius is a, and Height equal to $\frac{x}{2} - \frac{xx}{4a} + \frac{xxx}{12aa}$.

And the whole Curve Surface of the Solid infinitely continued, is equal to *one third Part of the Curve Surface of a Cylinder whoſe Radius and Height are equal to* FH or a. Which may be demonſtrated after the Manner of the precedent Propoſition.

7. The

7. The Radius of the Curvature of any Particle of the Quadratrix is $\frac{t\,t}{a-x}$ and this found Geometrically. FAE is the *Quadratrix*, Fig. 13. HD the Aſymptote, AD the Tangent, BD the Subtangent to a given Point A. Make $BV = AD$. Upon V raiſe the Perpendicular VW, from A draw AW perpendicular to the Tangent AD, till it meet AW in W. So is AW the Radius of the Curvature at A.

8. This Curve may be continued on infinitely above the Point F (but by a different and more operoſe Way of Conſtruction) whoſe Properties will be theſe. 1. The *Difference* of its Tangent and Subtangent (taking the Subtangent in the Line HS) will be always equal to the ſame given Line FH or a. That is, as $t + s = a$, below F, ſo $t - s = a$ above F. 2. As below F the Curve Line is equal to the *Sum* of its Ordinate and Subtangent, ſo above, it is equal to their *Difference* or $-S-y$. 3. As below F, $2\,a\,y = I\,L\,M$, ſo above $2\,a\,y = I\,\lambda\,\mu$. All which (and its other Properties) may be demonſtrated as the Precedent *mutatis mutandis*.

9. With a little Variation in the precedent Conſtruction, may the *Logarithmick Curve* be conſtructed, which is alſo a *Quadratrix* to the Hyperbola. Fig. 11. Omitting the String MRP, let the Diſtance MR be equal to the *Subtangent* of the intended Logarithmick Curve (which, as 'tis known, is invariable.) Stick a Pin at R in the Rular CD, to which apply the Rular EF, ſo that the Edge of the little Quadrant kl, reſting upon the Rular AB, the Diſtance Mi be equal to MR. Then keeping the Rular EF tight to the Pin R and Rular AB, ſlide the Rular CD along in a ſtrait Line (by the Rular or Line SO.) So will the Wheel $g\,h$ deſcribe a Part of the Logarithmick Curve TV, whoſe *Subtangent* is every where MR.

10. Let FAE repreſent the *Logarithmick Curve*, whoſe Subtangent is equal to FH. Fig. 12. $LI\Lambda$ is an Equilater Hyperbola (*&c.* as before § 3.) Let $FG = x$, $Ga = y$. $FH\,(=BD) = a$. $GH\,(=LS) = a - x$. $AC = \dot{x}$ $Ca = \dot{y}$. Then $AC : Ca :: AB : BD$, that is $\dot{x} : \dot{y} :: a - x : a :: a : \frac{a\,a}{a-x}$ therefore $a\,\dot{y} = \frac{a\,a}{a-x}\,\dot{x}$. The flowing Quantity of $a\,\dot{y}$ is $a\,y$; and the flowing Quantity of $\frac{a\,a}{a-x}\,\dot{x}$ is the Hyperbolick Area $FILG$ (for by the Nature of the Hyperbola $GL = \frac{a\,a}{a-x}$) therefore is the Hyperbolick Area $FILG$ equal to ay a Rect-

angle, whoſe Sides are the Subtangent ($BD = FH$) and Ordinate GA (as here accounted) of the Logarithmick Curve.

Of the Length of Curve *Lines, by Mr.* J. Craig, n. 314. p. 64.

IX. LEMMA.] *Duorum Quadratorum ſummam in alia duo Quadrata dividere.*

Sint dz^2, &c. ds^2 duo quadrata data, quorum ſumma $dz^2 + ds^2$ dividenda eſt in alia duo Quadrata dx^2, dy^2; ſintque m, & n duo quilibet numeri ad arbitrium ſumendi. Jam ex conditione Problematis eſt $dx^2 + dy^2 = dz^2 + ds^2$, unde (ut ex Diophanto conſtat)

$$\text{erit } dx = \frac{\sqrt{mm - nn \times dz + 2mn\,ds}}{mm + nn},$$

$$dy = \frac{\sqrt{nn - mm \times ds + 2mn\,dz}}{mm + nn} \ldots. \quad \text{Q. E. J.}$$

PROBLEMA.] *Curvas innumeras invenire, quæ ſint ejuſdem Longitudinis cum Curva quavis propoſita, ſive Algebraica ſive Tranſcendente.*

Deſignent z, s Coordinatas Curvæ propoſitæ; & x, y Coordinatas Curvæ quæſitæ, quæ ejuſdem ſit longitudinis cum propoſita; Unde ex Curvarum Elementis $dx^2 + dy^2 = dz^2 + ds^2$, Ideoque per Lemma præcedens

$$dx = \frac{\sqrt{mm - nn \times dz + 2mn\,ds}}{mm + nn},$$

$$dy = \frac{\sqrt{nn - mm \times ds + 2mn\,dz}}{mm + nn};$$

Quarum integrales ſunt

$$x = \frac{\sqrt{m^2 - n^2 \times z + 2mn\,s}}{mm + nn},$$

$$y = \frac{\overline{n^2 - m^2 \times s + 2mmz}}{mm + nn}.$$

Et ſic innoteſcunt Coordinatæ x, y unius ex Curvis quæſitis; ſimiliter ex hac una invenietur ſecunda, ex ſecundâ tertia, & ſic porro innumeræ invenientur .... *Q. E. F.*

Exempla jam non addo, nam poſtea opportunior dabitur locus, in quo Methodus hæc ad plura hujuſmodi Problemata extendetur, & Solutio Problematis hujus per Exempla illuſtrabitur. Et quidem hanc Solutionem ſemel iterumque tam apertè indicavi, ut facillimè à quovis in his verſato deduci poſſit ex iis, quæ ſubjunguntur Solutioni Caſûs ſpecialis hujus Problematis, in quo ſcil. Curva propoſita eſt Algebraica, quamque exhibui in Actis Phil. R. S. Jan. 1704, ut Clariſſimo Problematis propoſitori D. Jo. Bernoulli conſtaret illius Solutionem è Methodis Calculi differentialis inverſis maximè tritis poſſe obtineri, utpote qui in privatis ſuis ad D. Cheynæum Literis ſignificabat eandem non poſſe exhiberi per Theoremata noſtra in Actis Phil. R. S. Mart. 1703. publicata. Et quoniam ex Actis Erud. Aug. 1705. percipio ſolutionem illam (quæ ſcopo prædicto ſatis ſuperque ſatisfaciebat) Doctiſſimo Viro non arridere, ideo modo præmiſſam Solutionem nulli objectioni obnoxiam publici juris facio. Neceſſe itaque eſt ut Clariſſ. Bernoulli agnoſcat vix ullum dari Problema, cujus Solutio ex Calculo Integrali facilius deducitur, quam ſui de Transformatione Curvarum.

Vid. *ſup.* S. VII.

Vid. *ſup.* S. VI.

Quæ verò in ipſius Bernoulli Solutione diſplicent paucis enarrabo. Et Primo, Quod ad Curvas tantum Algebraicas eandem extenderit. Secundo, Quod Mechanica tantum ſit, à Motu (ut vocat) Reptorio tota dependens. Immortali quidem honore dignus eſt Hugenius ob inventum Evolutionis Motum, quia & ipſe & poſt ipſum alii plurima egregia Theoremata Geometricè exinde deduxerunt. Sed nec Motus Leibnitii Tractionis, nec Bernoulli Motus reptorius cum Hugenii Motu evolutionis comparabuntur, donec cum Hugenio celeberrimi viri Curvas per Motus ſuos genitas ad leges Geometricas revocaverint; quod cum neuter eorum præſtiterit, ideo Problematum Solutiones dependentes à Curvis per Motus ſuos genitis inter Mechanicas ſolum annumerari poſſunt.

X. In Actis Eruditorum pro menſe *Octobri* Anni 1698. pag. 471. D. *Johannes Bernoullius* hæc ſcripſit. " Methodum quam optaveram " generalem ſecandi [Curvas] ordinatim poſitione datas, ſive algebrai- " cas ſive tranſcendentales, in angulo recto ſive obliquo, invariabili " ſive data lege variabili, tandem ex voto erui: cui, *Leibnitio* appro- " batore, ne γρῦ addi poſſet ad ulteriorem perfectionem, & vel ideo tan-

A General Solution of a Problem *concerning* Curves, *by* ---- n. 347. p. 399.

" tum quod perpetuo ad æquationem, deducat: in quaſi interdum in-
" determinatæ ſunt inſeparabiles, methodus non ideo imperfectior eſt,
" non enim hujus ſed alîus eſt methodi indeterminatas ſeparare. Ro-
" gamus igitur fratrem ut velit ſuas quoque vires exercere in re tanti
" momenti. Suſcepti laboris non pœnitebit, ſi felix ſucceſſus fructu
" jucundo compenſaverit. Scio relicturum ſuum quem nunc fovet
" modum, qui in pauciſſimis tantum exemplis adhiberi poteſt.

Hi tres Viri celeberrimè ſeſe, jam ab annis quatuor vel quinque circiter, in ſolvendis hujuſmodi Problematibus exercuerant. Abſque ſpiritu divinandi eandem ſolutionem cum *Bernoulliana* tradere difficile fuerit. Sufficit quod Solutio ſequens ſit generalis, & ad æquationem ſemper deducat.

PROBLEMA.] *Quæritur Methodus generalis inveniendi Seriem Curvarum, quæ Curvas in ſerie alia quacumque data conſtitutas, ad angulum vel datum vel data lege variabilem ſecabunt.*

Solutio.] Natura Curvarum ſecandarum dat Tangentes earundem ad interſectionum puncta quæcunque; ad anguli interſectionum dant perpendicula Curvarum ſecantium; & perpendicula duo coeuntia, per concurſum ſuum ultimum, dant centrum Curvaminis Curvæ ſecantis ad punctum interſectionis cujuſcumque. Ducatur Abſciſſa in ſitu quocumque commodo, & ſit ejus Fluxio unitas; & poſitio perpendiculi dabit Fluxionem primam Ordinatæ ad Curvam quæſitam pertinentis; & Curvamen hujus Curvæ dabit Fluxionem ſecundam ejuſdem Ordinatæ. Et ſic Problema ſemper deducetur ad æquationes. Quod erat faciendum.

Scholium.] Non hujus ſed alîus eſt methodi æquationes reducere, & indeterminatas ſeparare, abſolutè ſi fieri poſſit, ſin minus per Series infinitas. Problema hocce, cum nullius fere ſit uſus, in Actis Eruditorum annos plures neglectum & inſolutum manſit. Et eadem de cauſa ſolutionem ejus non ulterius proſequor.

Mr. Leibnitz's *Problem concerning* Curves, *ſolv'd by Dr.* B. Taylor, n. 354. p. 695.

XI. Cum Dom. *G. G. Leibnitius* nuper defunctus, in controverſiâ jampridem orbâ circa Inventionem Methodi Fluxionum (quam is *Differentialem* vocare maluit, ſibique pertinaciter appropriari niſus eſt) nihil omnino reſponſi dederit argumentis, quibus inclyti iſtius Inventi Dom. *Newtono* vendicatur; en tandem hortante Dom. *Joh. Bernoulli* Problema Geometris *Anglis* ſolvendum propoſuit; ſed ſive Problema ſolvatur, ſive inſolutum maneat, nihil exinde conſequitur quod *Newtonum* afficiat: verum ne aliquando exinde occaſionem triumphandi arripiant, ſi hoc Problema maneat ab *Anglis* omnino intactum, ipſe inducor ut ſolutionem edam qualem qualem Problematis, nec uſu nec difficultate adeo inſignis.

Problema à *Leibnitio* primo propoſitum ita fuit intellectum, quaſi nihil aliud requiſitum fuiſſet, quam ut ſecarentur ad Angulos rectos Hyperbolæ Conicæ iiſdem Centro & Verticibus deſcriptæ. Verum cum illi nunciatum fuerat hunc caſum à quibuſdam *Anglis* fuiſſe illicò ſolutum, reſcripſit,

reſcripſit, non ſolutionem casûs particularis, ſed generalem requiri. Quo factum eſt ut ſolutiones iſtæ particulares non editæ fuerint; verùm in Tranſactione Philoſophicâ N° 347. ſubinde prodiit Solutio maximè generalis. Sed nec illâ contenti fuerunt *Leibnitius* & Fautores ejus, quin illam deriſui habuêre, quaſi qui illam excogitaverat non potuiſſet eam ad caſum ſpecialem applicare. Si nondum viderint quomodo ex illâ æquationes ſint deducendæ, id profectò illorum imperitiæ tribuendum erit. Paulo ante *Leibnitii* obitum prodiit tandem Problema ſequens; quod quidem diverſimodè ſolvi poteſt, premendo veſtigia Solutionis generalis modò citatæ, ſed quod in præſentia ſolvimus ut ſequitur. *Vid.* ſupra, S. X.

Problema.] *Super rectâ* A G *tanquam axe, ex puncto* A *educere infinitas Curvas, qualis eſt* A B D, *ejus naturæ, ut radii Oſculi, in ſingulis punctis* B *& ubique ducti,* B O *ſecentur ab axe* A G *in* C, *in datâ ratione, ut nempe ſit* B O *ad* B C *ut* 1 *ad* n. Fig. 14.

Deinde conſtruendæ ſunt Trajectoriæ E B F *primas curvas* A B D *normaliter ſecantes.*

Solutionis Pars prima.] *Nempe Inventio Curvarum ſecandarum* A B D.

1. Ductâ ordinatâ BH ad axem AG normali, ſint, Abſciſſa $AH = z$, Ordinata $HB = x$, Curva $AB = v$. Tum per Methodum Fluxionum directam erit $BC = \frac{\dot{v}}{\dot{z}}\dot{x}$, & fluente uniformiter v, $BO = \frac{\dot{v}\dot{x}}{\ddot{z}}$. Unde per conditionem Problematis fit $BO\left(\frac{\dot{v}\dot{x}}{\ddot{z}}\right) : BC\left(\frac{\dot{v}}{\dot{z}}\dot{x}\right) :: 1 : n$; adeoque $\ddot{z}\dot{x} - n\dot{z}\dot{x} = 0$.

2. Collatâ hâc æquatione cum formulâ Fluxionum ſecundâ, in calce *Prop.* 6. Methodi Incrementorum, invenitur $\dot{z}\dot{x}^{-n} = \dot{v}\dot{\alpha}^{-n}$; exiſtente α linea data, per cujus valorem poteſt Curva ABD accommodari conditioni alicui Problemati annexæ.

3. Pro $\dot{v}$ ſcripto ipſius valore $\sqrt{\dot{x}^2 + \dot{z}^2}$, migrat æquatio $\dot{z}\dot{x}^{-n} = \dot{v}\dot{\alpha}^{-n}$ in hanc $\dot{z} = \frac{\dot{x}\,x^n}{\sqrt{\alpha^{2n} - x^{2n}}}$. Unde datur z ex datâ x, per quadraturam Curvæ cujus abſciſſâ exiſtente x eſt ordinata $\frac{x^n}{\sqrt{\alpha^{2n} - x^{2n}}}$.

4. Sint σ & τ numeri integri, vel affirmativi vel negativi, tales ut ſit Curvarum iſto modo provenientium ſimpliciſſima, ea cujus eſt Abſciſſâ y, &

& Ordinata $y \frac{1-n+2\sigma n}{2n} \times \overline{\alpha - y}^{\tau \frac{1}{2}}$; tum erit ea omnium Curvarum ſimpliciſſima, per quarum Quadraturam datur Abſciſſa z ex datâ Ordinatâ x.

5. Eſt Curva ABD Geometrica, quoties pro n ſumitur reciprocum numeri cujuſvis imparis.

6. In prædictis Curvam ABD conſideravimus ut verſus axem AG concavam, quo in caſu maxima ordinata x æqualis eſt lineæ datæ α, quam Parametrum Curvæ commodè vocare licet. Et in hoc caſu Curva actu occurret Axi. Unde fluente ipſius $\frac{\dot{x}\, x^n}{\sqrt{\alpha^{2n} - x^{2n}}}$ debitè ſumptâ, hoc eſt, ita ut ſimul evaneſcant z & x, tranſibit Curva per punctum datum A, ſicut poſtulat Problema.

7. Sed ſi quæratur Curva ABD, quæ ſit verſùs axem convexa, ad eundem modum pervenietur ad æquationem $\dot{z} = \frac{\alpha^n \dot{x}}{\sqrt{x^{2n} - \alpha^{2n}}}$; quæ etiam ex æquatione priori derivari poteſt mutando ſignum ipſius n. Et in hoc caſu eſt curva ABD Geometrica, quoties pro n ſumitur reciprocum cujuſvis numeri paris. In hoc verò caſu Ordinata omnium minima x æqualis eſt Parametro α; adeoque Curva nuſquam occurrit Axi. Quare limitatur Problema ad caſum priorem.

8. Ex præmiſſis facilè colligitur Curvas omnes ABD eſſe inter ſe ſimiles, & circa punctum datum A ſimiliter poſitas, lateribus earum homologis exiſtentibus proportionalibus Parametris α.

Solutionis Pars altera.] *Nempe Inventio Curvæ ſecantis.*

9. Ex § 2. fit $\dot{v} : \dot{z} :: \alpha^n : x^n$. Sed eſt $BC : BH :: \dot{v} : \dot{z}$, Unde fit $BC : BH :: \alpha^n : x^n$. Ex conditione verò Problematis eſt BC tangens Curvæ quæſitæ EBF. Quare ſi jam ſumantur $AH\,(z)$ & $BH\,(x)$ pro coordinatis Curvæ EBF, Curvâ ipsâ EB exiſtente r, erit, Meth. Flux. direct. $\dot{r} : -\dot{x} :: (BC : BH ::)\ \alpha^n : x^n$. Unde ſit

$$\frac{x^n}{x^2} = \frac{-\dot{x}}{\dot{r}}.$$

10. In Curva ABD finge æquationem $\dot{z} = \frac{\dot{x}\, x^n}{\sqrt{\alpha^{2n} - x^{2n}}}$ transformari in

æqua-

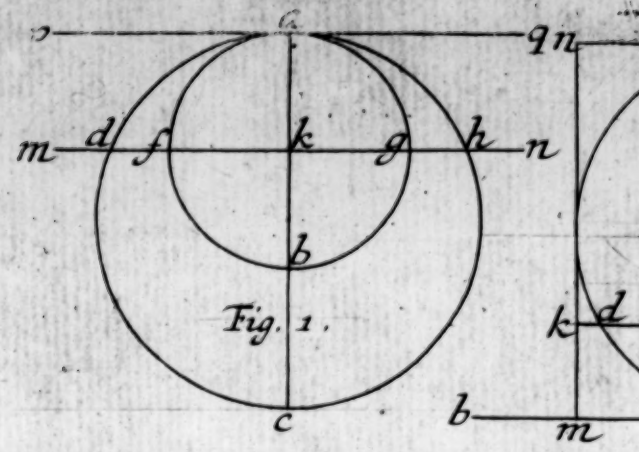


Fig. 1.

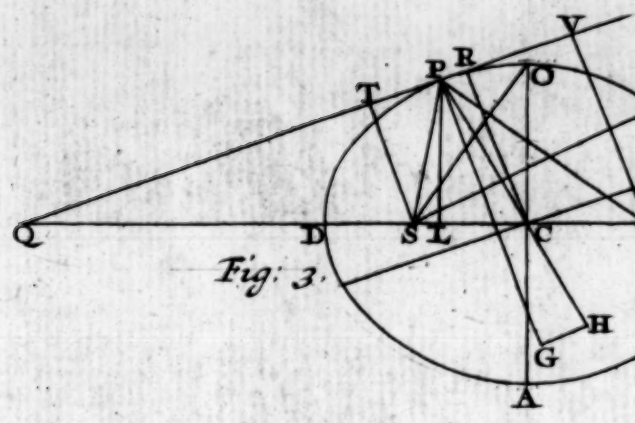
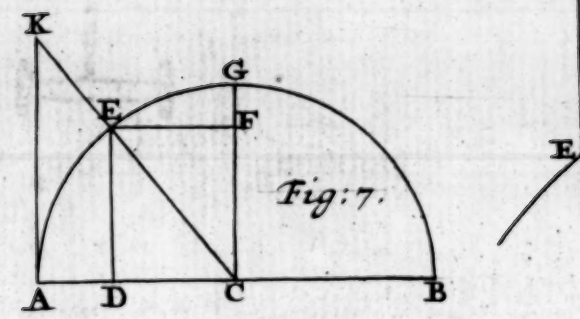


Fig. 3.



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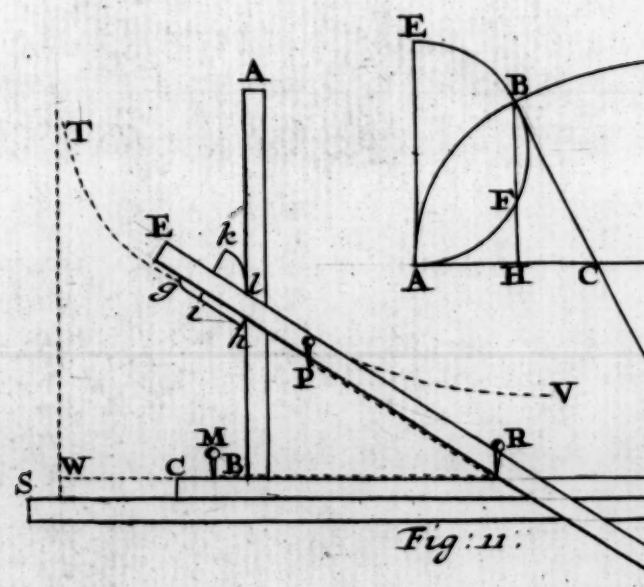
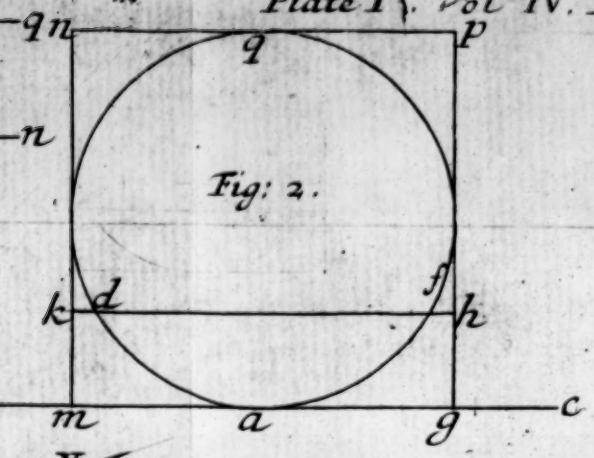


Fig: 11.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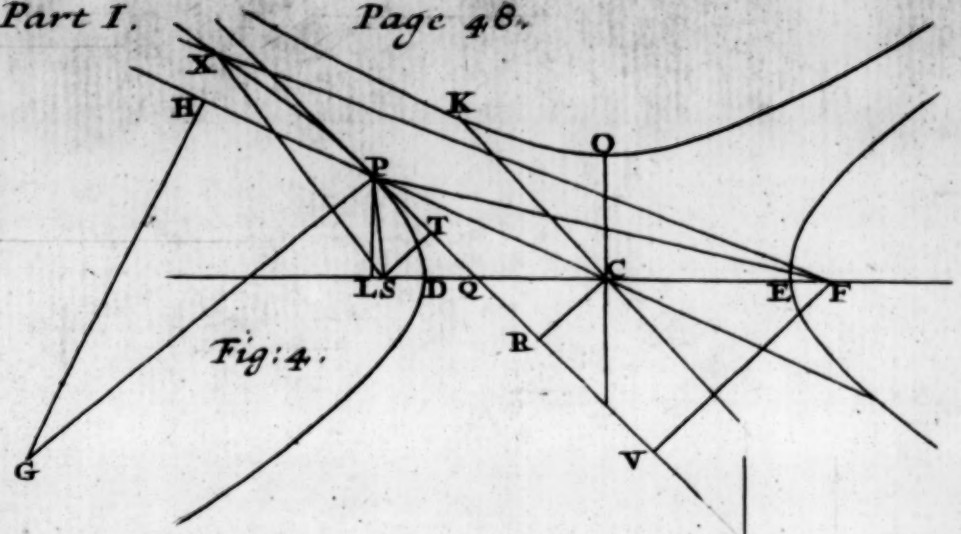
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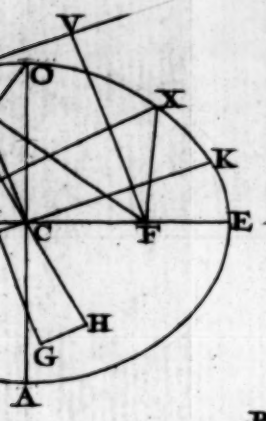
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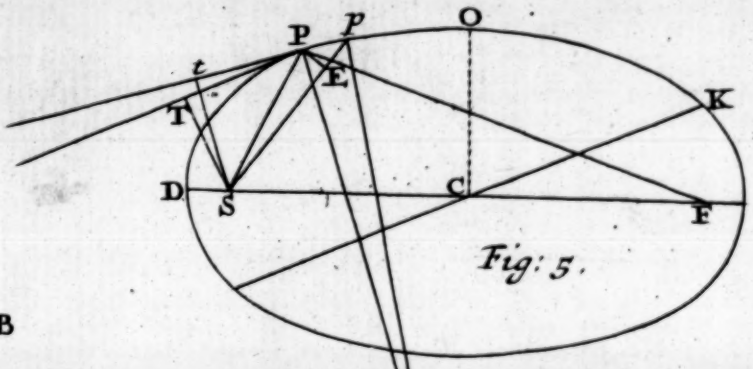
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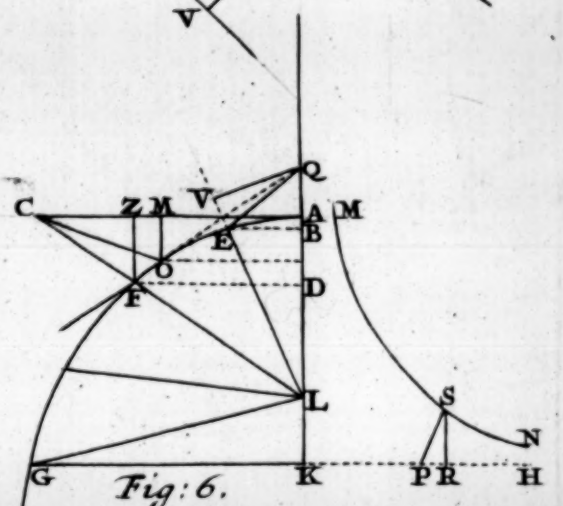
Fig: 5.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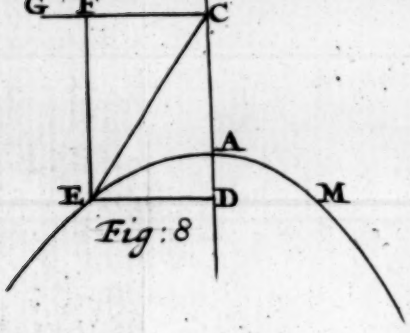
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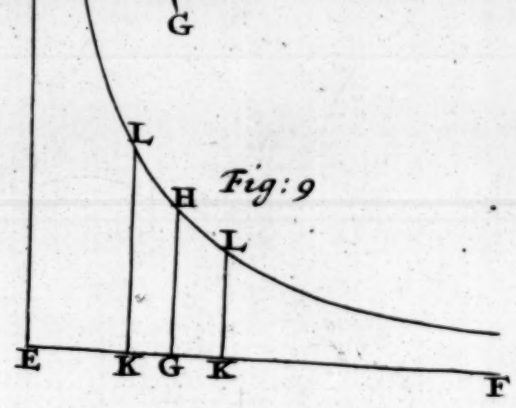
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Fig: 9
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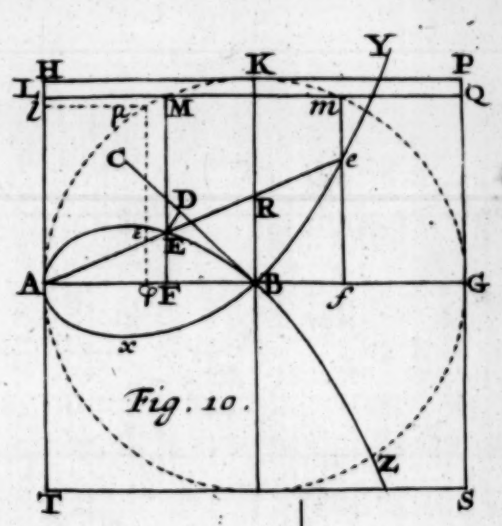
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Fig. 10.
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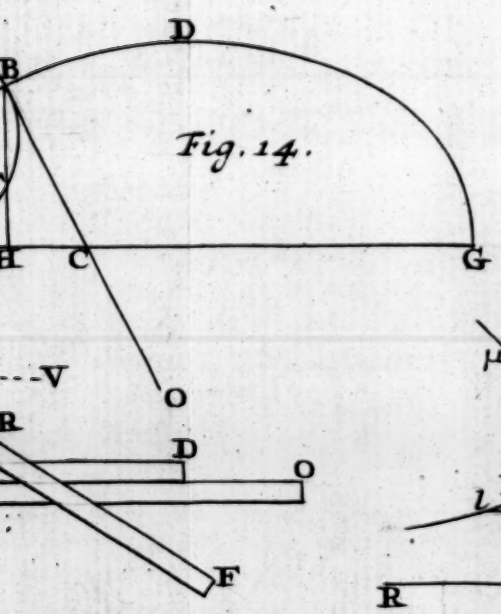
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Fig. 14.
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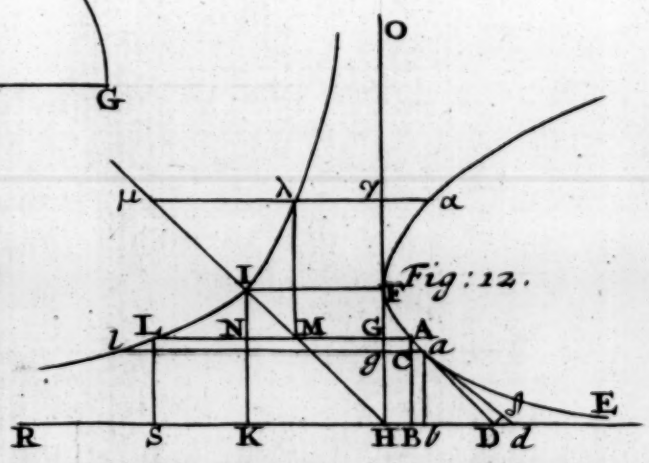
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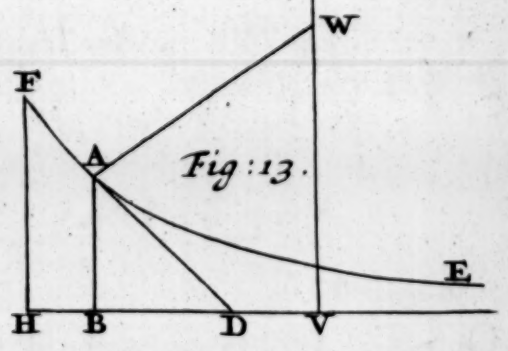
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Æquationem signis radicalibus non affectam $\dot{z} = A\dot{x}\frac{x^n}{a^n} + B\dot{x}\frac{x^{2n}}{a^{2n}} +$, &c.

Tum regrediendo ad fluentes fiet $z = \frac{1}{n+1}A\frac{x^{n+1}}{a^n} + \frac{1}{2n+1}B\frac{x^{2n+1}}{a^{2n}} +$, &c. coefficiente novâ introductâ nullâ, quoniam per conditionem Problematis debent simul nasci z & x. Hinc vice $\frac{x^n}{a^n}$ substituto ipsius valore $\frac{-\dot{x}}{\dot{r}}$ in §. 9. invento, fit $z = \frac{1}{n+1}Ax\frac{-\dot{x}}{\dot{r}} + \frac{1}{2n+1}Bx\frac{-\dot{x}^3}{\dot{r}^3} +$, &c. quæ Æquatio fluxionalis est primi gradûs ad Curvam quæsitam EBF. Revocatur autem ad formulam simpliciorem in terminis numero finitis, modo sequenti.

11. Fluat uniformiter r, & existente a quantitate non fluente, sit $\frac{-\dot{x}}{\dot{r}} = \frac{s^n}{a^n}$. Substituto hoc valore ipsius $\frac{-\dot{x}}{\dot{r}}$ in Æquatione novissimè inventâ, atque ductâ Æquatione in $\frac{s}{x}$, transformatur ea in hanc $\frac{\dot{z}s}{x} = \frac{1}{n+1}A\frac{s^{n+1}}{a^n} + \frac{1}{2n+1}B\frac{s^{2n+1}}{a^{2n}} +$, &c. Unde capiendo Fluxiones fit $\frac{\dot{s}zx + s\dot{z}x - sz\dot{x}}{x^2} = A\dot{s}\frac{s^n}{a^n} + B\dot{s}\frac{s^{2n}}{a^{2n}} = \frac{\dot{s}s^n}{\sqrt{a^{2n} - s^{2n}}}$. Quod ultimum constat ex Analogia Serierum $A\dot{x}\frac{x^n}{a^n} +$ &c. & $A\dot{s}\frac{s^n}{a^n} +$ &c. Hinc pro s & $\dot{s}$ substitutis eorum valoribus ex Æquatione $\frac{-\dot{x}}{\dot{r}} = \frac{s^n}{a^n}$ col-

lectis, elicitur æquatio $n\dot{x}^2\dot{z}z - \ddot{x}\dot{x}z\dot{z} - n\dot{x}\dot{x}\dot{z}^2 - \dddot{x}\dot{x}\dot{x}^2 = 0$. Quæ ad Fluxiones primas revocatur modo ſequenti.

12. In termino ultimo $-\dddot{x}\dot{x}\dot{x}^2$ vice $\dddot{x}\dot{x}$ ſcripto ipſius valore $-\ddot{z}\dot{z}$, & Æquatione deinde applicata ad $\dot{z}$, ſit $n\dot{x}^2z - \ddot{x}\dot{x}z - n\dot{x}\dot{x}\dot{z} + \dot{x}\dot{x}\ddot{z} = 0$. Quæ Æquatio in x^{-n-1} ducta eſt Fluxio æquationis $-\dot{x}x^{-n}z + x^{1-n}\dot{z} = a^{1-n}\dot{r}$; exiſtentibus a & $\dot{r}$ non fluentibus. Eſt ergo $-\dot{x}x^{-n}z + x^{1-n}\dot{z} = a^{1-n}\dot{r}$, ſeu $\overline{\dot{z}x - z\dot{x}} \times a^{n-1} = \dot{x}x^n$, æquatio fluxionalis primi gradûs ad Curvam quæſitam EBF.

13. In iſtâ autem Æquatione eſt a valor Ordinatæ BH, quando incidit punctum H in punctum A.

14. Haud proclive eſt Æquationem $\overline{\dot{z}x - z\dot{x}} \times a^{n-1} = rx^n$, manente n in terminis generalibus, revocare ad Æquationem fluentes tantùm involventem, vel ad quadraturam Curvarum. Sed puncta curvæ EBF poſſunt commodè inveniri per deſcriptionem Curvæ ABD, & Curvæ cujuſdam Geometricæ. Per Geometricam hîc intelligo Curvam, cujus Æquationem non ingrediuntur Fluxiones, nec fluentes in indicibus dignitatum. Secetur enim Curva ABD, cujus Parameter ſit a in B, à Curvâ geometricâ cujus Æquatio eſt $a\,a^n x^n - z\,a^n x^n = x\,a^n\sqrt{a^{2n} - x^{2n}}$; atque erit punctum illud interſectionis B ad unam ex Trajectoriis quæſitis, nempe quæ tranſit per punctum E, exiſtente $AE = a$ & normali ipſi AG.

15. Hinc ſi ABD ſit Curva geometrica, erit etiam EBF geometrica.

Scholium. Poteſt & alio modo inveniri Æquatio $\overline{\dot{z}x - z\dot{x}} \times a^{n-1} = \dot{r}x^n$. Nam certâ quâdam Analyſi quam nunc celare ſtatuo, inveni æquationem $\frac{\dot{a}}{a} = \frac{\dot{r}\dot{r}}{\dot{z}z + \dot{x}x}$. Quâ comparatâ cum Æquatione $\frac{x^n}{a^n} = \frac{-x}{r}$ (§. 9.) eliminando a & $\dot{a}$, tandem pervenitur ad prædictam Æquationem $\overline{\dot{z}x - z\dot{x}} \times a^{n-1} = \dot{r}x^n$.

Exemplum. Ad demonſtrationem Solutionis noſtræ ſuffecerit exemplum ſimpliciſſimum. Sit itaque $n = 1$; quo in Caſu eſt ABD ſemicirculus diametro AG deſcriptus, atque eſt EBF item ſemicirculus deſcrip-

deſcriptus diametro AE. Eſt autem in hoc Caſu $\frac{\dot{x}\,x^n}{\sqrt{\alpha^{2n}-x^{2n}}} = \frac{\dot{x}\,x}{\sqrt{a^2-x^2}}^n$.

Unde in § 3. fit $\dot{z} = \frac{\dot{x}\,x}{\sqrt{\alpha^2-x^2}}$; adeoque $z = \alpha - \sqrt{\alpha^{2n}-x^2}$, quæ Æquatio eſt ad Circulum diametro $AG = \alpha$ deſcriptum, ut fieri debuit. Item pro n ſcripto 1, æquatio $\dot{z}x - z\dot{x} \times a^{n-1} = \dot{r}x^n$ (§ 12.) migrat in hanc $\dot{z}x - z\dot{x} = \dot{r}x$. Unde exterminando $\dot{r}$ ope æquationis $\ddot{r}r = \ddot{x}x + \ddot{z}z$, fit $\frac{2\dot{z}zx - \dot{x}z^2}{x^2} = -\dot{x}$; adeoque regrediendo ad Fluentes $\frac{zz}{x} = -x + a$, quæ Æquatio eſt ad Circulum diametro $AE = a$ deſcriptum, ut etiam fieri debuit.

Conſtruction and Meaſure of Curves, *by Mr.* C. Maclaurin. n. 356. p. 803.

XII. Cum in omni linea curva ſit aliqua curvaturæ regularitas licet fortè implicata, ſecundum quam figura determinatur; ideo Geometræ varias Curvarum characteres ex Æquatione Ordinatarum relationem ad abſciſſas axis alicujus exprimente definiunt. Cum verò idem fieri poſſit ex conſideratione Curvarum reſpectu unius dati centri, imo ſimpliciſſima Naturæ uniformitas in ejus indagine id fieri ſæpe poſtulet, ideo hanc Curvas conſiderandi Methodum impræſentiarum uſurpabimus, & imprimis oſtendemus qua facillima ratione (ſecundum hanc Methodum *i. e.* ope Arithmeticæ Infinitorum Curvas determinandi) ex ſimplicibus complexores conſtrui poſſint.

S. 1.] Sint L & l puncta quam proxima in Curva BlL; ſit lo arcus centro S deſcriptus perpendicularis in SL; & erit Ll ut momentum Curvæ & Lo momentum Radii SL: Ac ſi detur ratio Ll ad Lo, vel ad lo in diſtantia SL, dabitur Æquatio Curvæ ad centrum S. Sint $LPlp$ Tangentes Curvæ in punctis L & l, in quas ex S demittantur normales SP, Sp iis occurrentes in punctis P & p ſimiliter in omnes Curvæ Tangentes demittantur perpendiculares ex dato puncto S, & conſtruetur Curva tranſiens per omnes Tangentium & perpendiculorum interſectiones. Hujus triangulum elementare Pnp ſimile erit triangulo Lol, quæ proinde dabitur ex data Curva BIL. Quippe ob æquales SnP, PnL, & rectos Spn, SPL, æquiangula erunt triangula Spn, PnL, & proinde $Pn : pn :: Ln : Sn :: Lo : lo$, adeoque ob angulos Pnp, SnL, Lol æquales, erunt triangula Pnp, SnL, Lol ſimilia. Cum igitur eadem ſit ratio Ll ad lo quæ Pp ad pn, & SL ad SP, manifeſtum eſt, datâ ratione Ll ad lo, & rectâ SL, dari rationem Pp ad pn & rectam SP, adeo- Fig. 15.

que Curvam DPp. Eadem ratione ex DP conſtrui poteſt Tertia, & ex ea dein Quarta, & progrediendo prodibit ſeries Curvarum infinita, quæ omnes ex uno dato innoteſcunt. Quod ſi erigantur LN & ln perpendiculares in radios Sl, Sl, ſibi mutuo occurrentes in n; & per omnia ſimiliter definita perpendicularium concurſuum puncta deſcribatur Curva EN: ea ipſa erit Curva ex qua deduci poteſt BL, eadem ratione qua conſtruximus DP ex BL. Ex EN ſimiliter conſtrui poteſt alia Curva, atque ex hac quoque parte Series infinita Curvarum conſtrui poterit.

S. 2.] Curvarum verò hac ratione conſideratarum ſimpliciſſimæ ſunt quarum Ll eſt ad Lo in ratione poteſtatis alicujus Radii, ita ut, ſi a ſit data quantitas, r denotet Radium Curvæ, n numerum quemcunque ſit Ll ad lo ut a^n ad r^n Æquatio earum generalis. Omnes verò hæ Apſidem habent cum $r = a$, quoniam in eo caſu $Ll = lo$. Ut inveſtigem Æquationem Curvæ DP, cum in BL eſt ut

Ll ad lo ita a^n ad r^n, ita r ad $SP = \frac{r^{n+1}}{a^n}$, ita $\frac{n}{a^{n+1}} \times SP\ \frac{1}{n+1}$

ad SP, ita $\frac{n}{a^{n+1}}$ ad $SP\ \frac{n}{n+1}$, ita Pp ad pn. Proinde ſi s repræſentet momentum Curvæ, y arcum circularem radio deſcriptum à centro S, & r radium correſpondentem, quæcunque ſit Curva cujus Æquatio inveſtigatur, erit Æquatio Curvæ BL, $\dot{s} : \dot{y} :: \frac{n}{a^{n+1}} : \frac{n}{r^{n+1}}$. Angulus autem PSp erit ad Angulum LSl ut $\frac{pn}{SP}$ ad $\frac{lo}{SL}$, ſive ut $\frac{Pn}{SP}$ ad $\frac{Lo}{SL}$, vel (ſi SP dicatur x & SL, r) ut $\frac{\dot{x}}{x}$ ad $\frac{\dot{r}}{r}$ hoc eſt, (ob $\dot{x} = \frac{r^{n+1}}{a^n}$) ut $\frac{n+1}{r}\dot{r}$ ad $\frac{\dot{r}}{r}$, ſive ut $n+1$ ad 1. Hinc BSP eſt ad BSL ut $n+1$ ad 1; unde facilius abſque Tangentium ope duci poteſt Curva BP. Si ſumatur angulus BSP ad BSL in ratione $n+1$ ad 1, & in SP demittatur perpendicularis ex L, erit occurſus perpendiculi cum SP, in Curva BP prius Tangentium ope deſcripta. Fig. 16.

S. 3.] Oſtendimus quo pacto ex unâ ſeries Curvarum infinita deducitur; quo verò pacto ſingularum Longitudines ex illius & unius alterius Longitudinibus datis innoteſcant pergo demonſtrare. Cum angulus $SPp = SLl$, atque LSl ſit ad PSp ut 1 ad $n+1$, erit Ll ad Pp ut $\frac{SL}{n+1}$ ad Fig. 16.

$\overline{n+1}\,SP$, ſive (ob $SL : SP :: Ll : lo$) ut Ll ad $\overline{n+1}\,lo$, ac proinde $Pp = \overline{n+1}\,lo$: ſed $lo = ln - on = ln - LN + Nn$; ergo $Pp = \overline{n+1} \times \overline{ln - LN + Nn}$. Sed $ln - LN$ eſt momentum rectæ LN normalis in SL, Pp momentum Curvæ BP & Nn momentum Curvæ BN: Cumque BP, BN, BL ſimul evaneſcant in B, erunt in ratione momentorum, adeoque $BP = \overline{n+1} \times \overline{BN + \text{vel} - LN}$. Unde Curva BP eſt ad ſummam vel differentiam Curvæ penultimæ in Serie ejuſque Tangentis ab intermedia interceptæ, ut $n+1$ ad 1; ſive, ſi m ſit Index Æquationis Curvæ BP (quoniam $m = \frac{n}{n+1}$) ut 1 ad $1 - m$.

Hinc Primo in ſerie Curvarum infinitâ ſupra deſcriptâ, ſi dentur Longitudines duarum proximarum, dabuntur Longitudines omnium; quippe menſura cujuſvis pendet à menſura penultimæ ſemper in ſerie, & proinde unum par omnibus menſurandis ſufficiet: Si una Curva ſit rectis commenſurabilis, vel incommenſurabilis, erit integræ ſeriei pars dimidia rectis commenſurabilis vel incommenſurabilis. Hinc 2do. Licet Curvæ BP & BN eſſent rectis incommenſurabiles, differentia tamen Curvæ BP ab $n+1$ Curvæ BN eſſet æqualis aſſignabili rectæ. 3^{io}. Si Curva tranſit per S, rectâ LN evaneſcente in S, erit $BPS = \frac{BNS}{1-m}$.

S. 4.] Curvarum de quibus egimus, quarum nimirum $\dot{s} : \dot{y} :: a^n : r^n$, maximè inſignis eſt Circulus, exiſtente S in circumferentia, cujus Æquatio eſt $\dot{s} : \dot{y} :: a : r$, ut ex ſimilitudine triangulorum Lol, BLS. Fig. 17. manifeſtum eſt, adeoque $n = 1$; & proinde $m = \frac{n}{n+1} = \frac{1}{2}$, & Æquatio Curvæ BP erit $\dot{s} : \dot{y} :: a^{\frac{1}{2}} : r^{\frac{1}{2}}$, quæ ipſa eſt Æquatio *Epicycloidis* revolutione Circuli ſuper baſim ſibi æqualem revolventis, deſcripti, ad punctum ubi punctum deſcribens tangit baſim, quæ D^{no} *Paſchal* dicitur *la Limaçon de M. Roberval*, quamque *M. de la Hire* conſiderat ut *Conchoidem* Baſis Circularis, in Actis Academiæ Pariſienſis Anni 1708. Perpendiculares omnes LN, ln concurrunt in puncto B, adeoque $BN = 0$: unde $BP = \frac{BN + NL}{1-m} + 2BL$: Hinc Curva tota $BPS = 2BS$, Longitudo

gitudo *Epicycloidis* ſemper dupla eſt chordæ arcus in circulo correſpondentis. 2^do. Ex *Epicycloide* deſcribatur Curva $B \sqcap S$, eadem ratione qua *Epicycloidem* ex Circulo deſcripſimus: In hoc caſu $n = \frac{1}{2}$, & $m = \frac{n}{n+1} = \frac{\frac{1}{2}}{\frac{1}{2}+1} = \frac{1}{3}$, ac proinde Æquatio Curvæ $B \sqcap S$ erit $\dot{s} : \dot{y} :: a^{\frac{1}{3}} : r^{\frac{1}{3}}$. Longitudo Curvæ erit $\frac{BL+LP}{1-m} = \frac{3}{2}\overline{BL+LP} = \frac{3}{2}\overline{BL+LG}$, & proinde $B \sqcap$ eſt ſeſquiplus ſummæ Arcus circularis ejuſque Sinus recti. Quod ſi ſumatur $CD = BD$, & radio SD centro S deſcribatur Circulus occurrens rectæ SP in H, & ſit HK perpendicularis in BS; quoniam $DH = \frac{2}{3}BL$, erit $B \sqcap = DH + HK$. Hinc arcus $B \sqcap$ neque ſunt rectis neque arcubus circularibus commenſurabiles differentia tamen arcuum $B \sqcap$ & DH eſt recta HK. In puncto S evaneſcit LG, adeoque $B \sqcap S = \frac{1}{2}BLS$, unde tota Curva eſt ſeſcupla ſemicirculi. Nulla vero pars hujus Curvæ aſſignabilis commenſurari poteſt toti, nec integra Curva in data quavis ratione ſecabilis eſt, ita ut portiones rationem aſſignabilem habeant ad ſe mutuo aut ad totam. Si hæc curva in data aliqua ratione geometricè ſecari poſſet, conſtaret Quadratura Circuli, nam ſi *ex. gr.* eſſet $B \sqcap$ ad $B \sqcap S$ ut 1 ad m, & BL ad BLS ut 1 ad n, eſſet $B \sqcap = \frac{B \sqcap S}{m} = \frac{3\,BLS}{2m} = \frac{3n\,BL}{2m} = \frac{1}{2}\overline{BL+LG}$, unde eſſet $BL = \frac{mLG}{n-m}$ & $BLS = \frac{nm}{n-m}LG$. 3. Ex $B \sqcap S$ conſtruatur explicata methodo Curva BR, & quoniam $n = \frac{1}{3}$ erit $m = \frac{n}{n+1} = \frac{1}{4}$, atq; Æquatio Curvæ BR erit $\dot{s} : \dot{y} :: a^{\frac{1}{4}} r^{\frac{3}{4}}$. Hinc Longitudo Curvæ fiet $\frac{4}{3}2\overline{BL+P\sqcap}$ totalis verò Longitudo Curvæ $BRS = \frac{8}{3}$ diametri SB. Si harum Curvarum Conſtructiones continuentur, prodibit hujuſmodi ſeries Æquationum quæ facile producitur ad libitum.

Æqua-

Æquatio Circuli	1.	$\dot{s} : \dot{y} :: a : r$
Epicycloidis	2.	$\dot{s} : \dot{y} :: d^{\frac{1}{2}} : r^{\frac{1}{2}}$
Secundi	3.	$\dot{s} : \dot{y} :: a^{\frac{1}{3}} : r^{\frac{1}{3}}$
Tertii	4.	$\dot{s} : \dot{y} :: a^{\frac{1}{4}} : r^{\frac{1}{4}}$
Cujuſvis	n.	$\dot{s} : \dot{y} :: a^{\frac{1}{n}} : r^{\frac{1}{n}}$, &c.

Obſervare licet in genere, omnes quarum Indicum denominatores ſunt Numeri pares, perfectæ rectificationis eſſe capaces; cumque quævis ſit ad penultimam ut 1 ad $1-m$, perpendenti manifeſtum erit Curvæ cujuſvis longitudinem fore $= \frac{1}{1-m} \times \frac{1-2m}{1-3m} \times \frac{1-4m}{1-5m} \times \frac{1-6m}{1-7m}$ &c. $\times$ SB continuando ſeriem donec ad nihilum reducatur Fractio. Quod ſi Indicis denominator ſit numerus impar, Curvæ erunt perfectæ rectificationis incapaces, & earum arcus quicunque erunt ſibi mutuo, ipſis totis, rectis quibuſvis & arcubus Circularibus incommenſurabiles: exprimi verò poſſunt omnes arcubus circularibus & rectis: At Curvæ cujuſvis totalis Longitudo erit ad Semicirculum ut $\frac{1}{1-m} \times \frac{1-2m}{1-3m} \times \frac{1-4m}{1-5m}$, &c. ad unitatem. Denique ſi Areola à Corpore in harum quavis revolvente ſumatur conſtans, hoc eſt ſi $r\dot{y} = 1$, ſubtenſa anguli contactus, cui ſemper (ob datum datâ areâ tempus) proportionalis eſt *Vis Centripeta* tendens ad S, erit reciprocè ut poteſtas diſtantiæ cujus Index eſt $2m+3$; atque hoc eſt non contemnendum harum Curvarum privilegium, quod in iis omnibus Vis centripeta tendens ad S ſit ut aliqua reciproca diſtantiæ dignitas, quæ ſimpliciſſima eſt, & utiliſſima in Naturæ indagine, Virium Centripetarum lex.

S. 5.] Curvarum quarum $\dot{s} : \dot{y} :: a^n : r^n$ proximè conſideranda venit (quæ Curva quidem improprie dicitur) ipſa Linea recta, exiſtente *S* extra rectam. In hac linea, ob ſimilia triangula P*pn*. PBS erit (ſi BS $= a$ & SP $= r$) $\dot{s} : \dot{y} :: r : a$. Ex linea recta methodo directâ nihil niſi punctum B conſtrui poteſt, Methodo vero inversâ, perpendicularium nimirum PL, *pl* concurſu, conſtrui poteſt Curva, cujus Index (ſi *m* ſit Index Curvæ BP) æqualis erit $\frac{m}{1-m}$; nam ſi Index Curvæ BL ſit *n*, erit Fig. 18.

r, erit $m = \frac{n}{n+1}$, ac proinde $n = \frac{m}{1-m}$. Unde in hoc caſu, cum $m = -1$ erit $n = \frac{-1}{2}$, & Æquatio Curvæ BL erit $\dot{s} : \dot{y} :: r^{\frac{1}{2}} : a^{\frac{1}{2}}$, quæ Æquatio eſt Parabolæ ad Focum. Ex hac conſtrue aliam, conſtituendo angulum LSN = LSB & erigendo LN normalem in SL occurrentem ipſi SN in N. Quoniam vero $m = \frac{-1}{2}$ erit $n = \frac{-1}{3}$, & Æquatio Curvæ $\dot{s} : \dot{y} :: r^{\frac{1}{3}} : a^{\frac{1}{3}}$ & $BP = \frac{BN - LN}{1-m} = \frac{1}{2}\overline{BN - LN}$, ergo $BN = 2BP + LN$; proinde hæc Curva eſt rectificabilis. Si Series continuetur, prodibunt ut prius Æquationes in hoc ordine.

Æquatio Rectæ	$\dot{s} : \dot{y} :: r : a$
Parabolæ	$\dot{s} : \dot{y} :: r^{\frac{1}{2}} : a^{\frac{1}{2}}$
Secundæ	$\dot{s} : \dot{y} :: r^{\frac{1}{3}} : a^{\frac{1}{3}}$
Tertiæ	$\dot{s} : \dot{y} :: r^{\frac{1}{4}} : a^{\frac{1}{4}}$
Cujuſvis	$\dot{s} : \dot{y} :: r^{\frac{1}{n}} : a^{\frac{1}{n}}$

In hac Serie primæ ſunt Recta & Parabola unde patet dimidiam hujus ſimiliter ac prioris Seriei eſſe rectis menſurabilem: alia vero dimidia pars in rectis & arcubus Parabolicis exhiberi poteſt. In his omnibus Vis centripeta ad S eſt reciprocè ut poteſtas diſtantiæ cujus Index $3 - 2m$, ac proinde ſemper inter duplicatam & triplicatam rationem diſtantiæ reciprocè.

S. 6.] Æquatio Hyperbolæ æquilateræ ad centrum eſt $\dot{s} : \dot{y} :: r^2 : a^2$, ex qua deducitur methodo directa Series hujuſmodi,

1.	$\dot{s} : \dot{y} :: r^2 : a^2$
2.	$\dot{s} : \dot{y} :: a^2 : r^2$
3.	$\dot{s} : \dot{y} :: a^{\frac{2}{3}} : r^{\frac{2}{3}}$
4.	$\dot{s} : \dot{y} :: a^{\frac{2}{5}} : r^{\frac{2}{5}}$
5.	$\dot{s} : \dot{y} :: a^{\frac{2}{2n-1}} : r^{\frac{2}{2n-1}}$

Ex

Ex his Curvæ, quarum Indicum denominatores ſunt in progreſſione —1, 3, 7, 11, *&c.* exhiberi poſſunt in rectis & arcubus Hyperbolicis; reliquæ verò in rectis & arcubus Curvæ, cujus Æquatio ad axem *SB* (ſi *x* ſit abſciſſa, *y* verò Ordinata) eſt $\overline{xx+yy}|^2 = a^2x^2 - a^2y^2$, quæque conſtruitur (*vid. Fig.* 17.) biſecando angulum *BSL* & ſumendo *SN* mediam proportionalem inter *SB* & *SL*.

Curvæ quæ ex Hyperbola methodo inverſa conſtrui poſſunt progrediuntur in hac Serie,

Hyperbolæ 1. $\dot{s} : \dot{y} :: r^2 : a^2$

2. $\dot{s} : \dot{y} :: r^{\frac{2}{3}} : a^{\frac{2}{3}}$

3. $\dot{s} : \dot{y} :: r^{\frac{2}{5}} : a^{\frac{2}{5}}$

Ubi Curvæ quarum Indicum denominatores ſunt in progreſſione 1, 5, 9, 13, *&c.* exprimi poſſunt in rectis & arcubus Hyperbolicis: reliquæ verò in rectis & arcubus Curvæ modo explicatæ.

Si aliæ Curvæ deſiderentur quæ alias exhiberent Series, id facillime fieri poteſt ope vel Circuli vel Rectæ: quippe ex earum aliqua omnes, in quibus $\dot{s} : \dot{y} :: \overset{n}{a} : \overset{n}{r}$, conſtrui poſſunt, ſumendo, ſi ope Circuli Problema ſit ſolvendum, *BSR* ad *BSL* ut 1 ad *n*, & *SN* in ipſa $SR = a^{\frac{n-1}{n}} \times SL^{\frac{1}{n}}$; quippe Curvæ per omnia puncta *N* ductæ Æquatio erit $\dot{s} : \dot{y} :: \overset{n}{a} : \overset{n}{r}$. Similiter ope Rectæ conſtrui poſſunt quarum Æquatio eſt $\dot{s} : \dot{y} :: \overset{n}{r} : \overset{n}{a}$. Fig. 19.

Duas exhibuimus Series infinitas Curvarum rectis commenſurabilium; aliam arcubus circularibus, aliam Parabolicis, aliam Hyperbolicis una cum rectis menſurabiles demonſtravimus; eæ vero ad rectarum menſuram arte ſola infinita reduci poſſe videntur, ſicut Æquatione ſola infinita in rectis exprimuntur.

XIII. Cum Methodum ſuam Cl. *Newtonus* ad Curvas tertii Ordinis puncto duplice carentes, aut eas altioris Ordinis puncto multiplice deſtitutas, non extendit; earumque deſcriptionem Problematibus Geometriæ difficilioribus annumerandam pronuntiat; ſpero Methodum ſequentem quâ Curvæ Geometricæ cujuſcunque Ordinis, licet puncto duplice aut multiplice quovis deſtitutæ (ſolâ datorum *Angulorum* & *Rectarum* ope) conſtruuntur, non fore Geometris ingratam. *A* New *Method of deſcribing all kinds of* Curves, *by Mr.* C. Maclaurin, n. 359. p. 939.

1. Lineæ primi ordinis ipſæ ſunt Rectæ; quæ in uno ſolo puncto ſibi mutuo occurrere poſſunt. Lineæ ſecundi Ordinis ſunt Sectiones Conicæ, quæ in pluribus punctis quam duobus à rectâ quavis ſecari non poſſunt. Eæ vero omnes ſecundum Lem. 21. Lib. I. *Princip.* D. *Newtoni* ſic conſtrui poſſunt. Circa data duo puncta C & S moveantur Anguli dati

Fig. 20. MCR, LSN, ita ut Crurum CM SL concurſus ſemper ducatur per rectam indefinitam poſitione datam AE; tunc crurum aliorum CR & SN concurſus in P deſcribet Lineam ſecundi Ordinis ſeu Sectionem Conicam.

Fig. 21. 2. Moveatur ut prius Angulus MCR circa datum punctum C; Angulus vero datus LNQ ſemper percurrat Angulari ſuo puncto N rectam datam AE, ita ut crus NQ ſemper tranſeat per datum punctum S. 1. Si concurſus crurum CR & SN, tum punctum Q ducatur per rectam infinitam AB, concurſus crurum CM & NL, deſcribet Cur-

Fig. 22. vam Lineam tertii Ordinis punctum duplex habentem in C. 2. Reliquis manentibus, ſi crurum CM & NL concurſus ducatur per rectam indefinitam AB; concurſus crurum CR & SN in P deſcribet Curvam tertii Ordinis punctum duplex habentem in S.

Fig. 23. Exemplum Caſus 1. Sint anguli MCR, LNS recti, & AE, DB CS parallelæ; ſint quoque SA & SD normales reſpective in rectas AE & DB; ſitque SD = 2SA. Hiſce poſitis, ſi SD ſit minor recta CS, Curva ſecundum regulam Caſus primi deſcripta, erit Parabola Nodata cum Ovali, Speciei 68*væ* Curvarum D. *Newtoni*; Quod ſi SD = CS, Ovalis evaneſcit & nodus evadit Cuſpis, atque Curva deſcripta erit Parabola *Neiliana* ſeu ſemicubica; Si vero ſit SD major quam CS, erit Curva Parabola punctata Campaniformis Speciei 69*næ*.

Fig. 24. 3. Moveantur Anguli dati RMT, KNL, ita ut puncta M & N percurrant rectas indefinitas BM, DN reſpective; & crura RM, KN ſemper tranſeant per data puncta C & S. Si primo Crurum MT & NL concurſus Q ducatur per rectam indefinitam AQ; tunc concurſus crurum MR & NR in P deſcribet Lineam quarti Ordinis punctа duo duplicia habentem alterum in C, alterum vero in S. Sed ſe-

Fig. 25. cundo ſi crurum MR & NK concurſus ducatur per rectam indefinitam AQ; tunc concurſus crurum MT & NL deſcribet Lineam quarti Ordinis puncto duplice carentem.

Fig. 24. 4. Quod ſi in primo caſu hujus Conſtructionis rectæ CMR, SNK, una coincidant cum CS; tunc puncta C & S evadunt ſimplicia & Cur-

Fig. 26. va erit tertii Ordinis abſque puncto duplice. Exemplum, Sint rectæ BM, AQ, DN, ſibi mutuo parallelæ atque omnes perpendiculares in CS. Sint quoque Anguli RMT, KNL recti, & ſi ſecundum regulam primi Caſus deſcribatur Curva, Crura CMR, SNK una coincident cum CS; & hac conſtructione deſcribi poſſunt Curvæ D. *Newtoni* 10, 11, 20, 21, 40, ſecundum varias poſitiones punctorum C & S reſpectu trium rectarum BM, AQ, DN; Omnes vero hæ Species puncto duplice carent.

Fig. 27. 5. Lineæ vero quarti Ordinis quæ punctum triplex habent ſic conſtrui poſſunt. Sint tres rectæ AQ, BN, DM poſitione datæ; ſint etiam Anguli QCT, SNM & NML dati & invariabiles; percurrant puncta N & M rectas BN & DM, ita ut crus NQ ſemper tranſeat per datum punctum S: Revolvatur QCT circa C ita ut concurſus crurum CK, SN percurrat tertiam rectam AQ; tunc concurſus

crurum CT, ML deſcribet Lineam quarti Ordinis punctum triplex habentem in C.

6. Oſtendi quo pacto Lineæ quarti Ordinis deſcribi poſſunt, quæ punctum triplex habent aut duo duplicia; aliæ quæ unicum habent punctum duplex ſic commode deſcribuntur. Sint tres rectæ ut prius poſitione datæ, AQ, BN, DM, dentur etiam Anguli SNK, SML, RCT; ſint puncta N, M & S ſemper in eadem recta Linea; Moveantur puncta N & M ut prius per rectas BN, DM; Si concurſus crurum CR, NK ducatur per rectam indefinitam AQ. tunc concurſus crurum CT, ML, deſcribet Lineam quarti Ordinis habentem punctum duplex unicum in C. Hæ vero duæ ultimæ Propoſitiones novas Methodos ſuppeditant Lineas tertii Ordinis deſcribendi, tum quæ puncta duplicia habent, tum quæ iis deſtituuntur: Eæ vero in brevi hoc Methodi noſtræ Specimine ſunt omittendæ. Fig. 28.

7. Maneant Anguli atque rectæ ut in *Prop.* 3. Concurſus vero nunc rectarum MT, NK ducatur per indefinitam rectam AQ; & concurſus crurum MR & NL deſcribet Lineam quinti Ordinis punctum quadruplex habentem in S. Habeo etiam alias Methodos curvas deſcribendi quinti Ordinis, quæ punctum habent triplex, duplex, aut duo duplicia, vel nulla niſi puncta ſimplicia; ſed hæc ſufficiant ad ſimplicitatem & univerſalitatem Methodi demonſtrandam. Notandum vero in ſpecialibus ſimplicioribus Angulorum & rectarum circumſtantiis. Lineam aliquando migrare in curvam ordinis inferioris quam in *Prop.* explicatur; Imo ſingulæ Propoſitiones Methodos ſuppeditant particulares, curvas aliquas ordinis cujuſcunque inferioris deſcribendi. Fig. 29.

8. *Propoſitio Generalis.* Sumantur ad libitum Rectæ in eodem plano ubicunque poſitæ, quarum ſit numerus (n) ut BN, ER, FT. Sumantur etiam ad libitum aliæ rectæ ut DM, GL, & HK, *&c.* quarum ſit numerus (m). Sint Anguli CNR, NRT, RTQ, *&c.* atque anguli SML, MLK, LKQ, *&c.* invariati, dum puncta angularia N, R, T, M, L, K, percurrant rectas indefinitas BN, ER, FT, DM, GL, HK; ducatur concurſus crurum TQ & KQ per rectam indefinitam AQ; invenire ordinem curvæ quam concurſus cruris SM cum aliqua rectarum CN, NR, RT, TQ, *&c.* *ex gr.* cum RT, perpetuo tanget. Fig. 30.

In Serie rectarum CN, NR, RT, TQ, *&c.* denotet s numerum rectæ RT, cujus concurſu cum SM Curva eſt deſcribenda, à CN incluſivè; qui in hoc caſu eſt ternarius: erit Curva ordinis quem exprimit numerus $sm + s + n + 1$: unde in caſu quem figura deſignat, cum $s = m = n = 3$ erit Curva ordinis 16^{ae}.

In his deſcriptionibus Rectas ſolummodo atque Angulos dari poſtulavimus; ſed facilius ſæpe ſimpliciorum Curvarum ope complexiores deſcribuntur; atque Propoſitiones his non minus Univerſales huc pertinentes inveſtigavi: Eas vero cum harum demonſtrationibus utpote prolixis impræſentiarum omitto.

The Doctrine of Combinations and Alternations, by Major Ed. Thornycroft, n. 299. p. 1961.

XIV. In order to underſtand what follows, it muſt be obſerved, 1*ſt*, That as in the Notation of Powers, *aaaabbbcc* is deſigned by $a^4\ b^3\ c^2$, and univerſally *p* times the Poſition of *a*, *q* times the Poſition of *b*, *r* times the Poſition of *c*, by $a^p\ b^q\ c^r$, ſo in Things expos'd likewiſe; (unleſs where 'tis propoſed they ſhould be all different) which Indices, as they have here no relation to Powers, but expreſs only the Occurrences of thoſe Things to which they reſpectively belong; I therefore call Indices of Occurrences.

2*dly*, That as often as I ſhall hereafter mention the Combination or Alternations of the $p^i\ q^i\ r^i$ or s^i, (which conſidered by themſelves are capable of no Variation) I mean of thoſe Things whoſe Indices they are.

3*dly*, That *m* is generally put for the whole Number of Things expoſed, whether all different or not, *i.e.* equal to the Sum of their Indices; and *n*, for ſuch a Number of them, as each Combination and Alternation muſt conſiſt of; (unleſs preſuppoſed equal) which explains what is hereafter meant by the Combinations and Alternations of *m* Things taken *n* and *n*; or of *m* Things taken *m* and *m*; and the like Expreſſion, by whatever Symbols the Number of Things out of which the Combinations and Alternations are to be made, or of which they are to conſiſt, may be deſign'd.

Lemma 1.] If in a right Line, at any Diſtances, be placed any Number of Things *a b c d*, *&c.* the Number of the Intervals *a b*, *b c*, *c d*, *&c.* terminated each by two adjacent Things, is one leſs than the Number of Things.

For, whereas every Interval is terminated by two adjacent Things, if to any Number of Things, be added one Thing more, one Interval only is thereby added. *Q. E. D.*

Lemma 2.] The Number of the Alternations of *m* Things *a b c d*, *&c.* different from each other, taken *m* and *m*, is *m* times the Number of the Alternations of $m-1$ Things *a b c*, taken $m-1$ and $m-1$.

For (by *Lem.* 1*ſt*) the laſt Letter *d*, beſides the Poſition it hath, may have $m-2$ Poſitions, *viz.* in the Intervals which are between $m-1$ Things *a b c*; but it may alſo have one more, for it may be put firſt of all, it may therefore have *m* Poſitions; and thoſe in all the different Orders whereof $m-1$ Things are capable; which being all the poſſible Poſitions of *d*, in all the Varieties of *a b c*, is all the Variety whereof the whole Number of Things expoſed *a b c d*, *&c.* is capable. *Q. E. D.*

Lemma 3.] The Number of the Alternations of *m* Things *a b c d*, *&c.* different from each other, taken *m* and *m*, is equal to $m \times m-1 \times m\ m-2 \times m-3 \times m-4$, *&c.* continued to *m* Places.

For let $\overline{m}\ O$ expreſs the Number of the Alternations of *m* Things different each from other; $\overline{m-1}\ O$, of $m-1$ Things and the like.

'Tis evident that if $m=1$, it will be $\overline{m}\ O = m$; for there can be but one Order of one Thing.

And if *m* be greater than Unity, then will it be (by *Lem.* 2.) $\overline{m}\ O = m \times \overline{m-1}\ O = m \times m-1 \times \overline{m-2}\ O = m \times m-1 \times m-2 \times \overline{m-3}\ O =$, *&c.*

till we have an Equation conſiſting of m Places; *i. e.* $= m \times m-1 \times m-2 \times m-3 \times$ &c. continued to m Places. *Q. E. D.*

Lemma 4.] If $m\omega$ expreſs the Number of the Alternations of m Things $a^{\alpha}\ b^{\beta}\ c^{\gamma}\ d^{\delta}\ e^{\varepsilon}\ f^{\zeta}$, &c. taken m and m, and α the Number of p^{ι}, β the Number of q^{ι}, γ the Number of r^{ι}, it will be

$$m\omega = \frac{m \times m-1 \times m-2 \times m-3 \times m-4 \times m-5 \times \text{\&c. continued to } m \text{ Places.}}{\overline{p \times p-1 \times p-2 \times \text{\&c.}}^{\alpha} \times \overline{q \times q-1 \times \text{\&c.}}^{\beta} \times \overline{r \times r-1 \times \text{\&c.}}^{\gamma}}$$

each Series continued to p, q, r, &c. Places reſpectively.

For the Number of the Alternations of any Number of Things, however divided into Parts, is produc'd by a continual Multiplication of the Alternations of thoſe Things among themſelves reſpectively, which compoſe each Part, into the Number of their Alternations one amongſt the other; *i. e.* in the preſent Caſe (the ſeveral Occurrences being ſuppoſed to compoſe the ſeveral Parts, and conſequently the Number of the Alternations of the Things compoſing each Part equal to Unity) $m\omega =$ to the Number of the Alternations of the Things compoſing the Parts one amongſt the other; but the Number of their Alternations one amongſt the other, is the ſame in this Caſe, as if the Things expos'd, being all different, were divided into the ſame Parts; for the Things which compoſe each Part in both Caſes, are different from the reſt of the Things expos'd, *i. e.* by *Lem.* 3d.

$$m\omega = \frac{m \times m-1 \times m-2 \times m-3 \times m-4 \times m-5 \times \text{\&c. continued to } m \text{ Places.}}{\overline{p \times p-1 \times p-2 \times \text{\&c.}}\,\big|^{\alpha} \times \overline{q \times q-1 \times \text{\&c.}}\,\big|^{\beta} \times \overline{r \times r-1 \times \text{\&c.}}\,\big|^{\gamma}}$$

each Series continued to p, q, r, Places reſpectively. *Q. E. D.*

Lemma 5.] The Number of the Combinations of m Things $a\ b\ c\ d$, &c. different from each other, taken n and n, is equal to

$$\frac{m \times m-1 \times m-2 \times m-3 \times \text{\&c.}}{n \times n-1 \times n-2 \times n-3 \times \text{\&c.}}$$

each Series continued to n Places.

For if the Things expos'd be divided in two Parts, *viz.* in the *Ratio* of n and $m-n$, 'tis evident that their different Combinations taken n and n, are produc'd by the Alternations of the Things compoſing the Parts one amongſt the other: And therefore the Number of thoſe $=$ to the Number of theſe $=$ to the Number of the Alternations of m Things taken m and m, the Indices of whoſe Occurrences are n and $m-n$ $= \frac{m \times m-1 \times n-2 \times m-3 \times \text{\&c. continued to } m \text{ Places.}}{n \times n-1 \times \text{\&c.} \times m-n \times m-n-1 \times \text{\&c.}}$ each Series continued to n and $m-n$ Places reſpectively (by *Lem.* 4th.) *i. e.* becauſe $n+m-n=m = \frac{m \times m-1 \times m-2 \times m-3 \times \text{\&c.}}{n \times n-1 \times n-2 \times n-3 \times \text{\&c.}}$ each Series continued to n Places. *Q. E. D.*

But the Number of the Alternations in every Combination is $= n \times n-1 \times n-2 \times n-3 \times$, &c. continued to n Places, by *Lem.* 3d. therefore

Lemma

Lemma 6.] The Number of the Alternations of m Things $a\,b\,c\,d$, &c. different each from other, taken n and n, is $= m \times m - 1 \times m - 2 \times m - 3 \times$, *&c.* continued to n Places. *Q. E. D.*

Scholium.] Since in the Things expoſed the ſame Things may occur more than once, and alſo n be leſs than m, the Indices of the Occurrences which are in ſome of the Combinations of m Things taken n and n, may differ from thoſe which are in others; but thoſe Combinations, the Indices of whoſe Occurrences are the ſame, are ſaid to be in the ſame Form: Therefore whereas n is equal to the Sum of the Indices which are in each Combination taken n and n, if n be expreſſed by all the different Combinations of ſuch Indices only (being integer Numbers) whereof no one may exceed the higheſt Index of the Things expoſed, and being more than one in a Combination, are each of them, which are in the ſame Combination, comprehended in a diſtinct Index thereof; theſe Expreſſions of n will neceſſarily be the ſeveral Forms of the Combinations taken n and n, whereof m Things are capable: Whence is derived a general Theorem for finding the Combinations and Alternations of m Things taken n and n univerſally: *i. e.* Whether m conſiſt of Things all different or not, and whether n be equal to, or leſs than m.

Theorem.] If n be expreſſed, according to all the different Forms of Combination which the Things expoſed are capable of,

and $\left\{\begin{array}{l} p = \text{the higheſt Index} \\ q = \text{the next higheſt} \\ r = \text{the next higheſt} \\ s = \text{the next higheſt} \\ \quad \&c. \end{array}\right.$ $\left\{\begin{array}{l} \alpha = \text{the Number of } p' \\ \beta = \text{the Number of } q' \\ \gamma = \text{the Number of } r' \\ \delta = \text{the Number of } s' \end{array}\right\}$ In every Form of Combination.

$\left\{\begin{array}{l} A = \text{the Number of all Indices not leſs than } p \\ B = \text{the Number of all Indices not leſs than } q \\ C = \text{the Number of all Indices not leſs than } r \\ D = \text{the Number of all Indices not leſs than } s \\ \quad \&c. \end{array}\right\}$ Which are in the Things expoſed.

and $b = \alpha + \beta$, $c = b + \gamma$, $d = c + \delta$, *&c.*

I ſay the Number of the Combinations of m Things taken n, and n in any one Form of Combination, ſhall be $\frac{A \times A-1 \times A-2}{\alpha \times \alpha-1 \times \alpha-2}$ *&c.*

$\times \frac{B-\alpha \times B-\alpha-1}{\beta \times \beta-1} \times \&c. \frac{C-b \times C-b-1}{\gamma \times \gamma-1} \times \&c. \times \frac{D-c \times D-c-1}{\delta \times \delta-1}$ *&c.*

continued to ſo many Terms as there are different Indices in the Form of Combination, and each Term to α, β, γ, δ, *&c.* Places reſpectively, and this Number multiplied into

$\times n$

$\times n--1 \times n--2 \times n--3 \times n--4 \times n--5 \times n--6$ &c. continued to n Places.

$\overline{p \times p--1 \times p--2 \times \&c.}\,|^{\alpha}\,\overline{\times q \times q--1 \times \&c.}\,|^{\beta}\,\overline{\times r \times r--1 \times \&c.}\,|^{\gamma} \times$ &c. each Series continued to $p\,q\,r$ &c. places reſpectively, ſhall be the Number of their Alternations.

But the Sum of all the Combinations and Alternations which are in every Form of n, ſhall be the whole Number of Combinations and Alternations of m Things taken n and n.

Demonſtration.] Firſt then 'tis evident, That thoſe Combinations which are in different Forms, differ from each other.

Again, 'Tis evident that the Combinations of m Things, as $a^p\,b^p\,c^p\,d^p\,e^q\,f^q\,g^q\,h^r\,i^r$, &c. (the Indices ſimply conſidered) taken n and n, in a Form wherein are $p'\,q'\,r'$, ſhall be equal to the Number of the Combinations of the p', which are in the Things expoſed, taken α and α, multiplied into the Number of the Combinations of the q' taken β and β, multiplied into the Number of the Combinations of the r' taken γ and γ.

But becauſe p and all leſſer Indices are comprehended in every Index, which is greater than themſelves; therefore is $A =$ to the Number of p', which are in the Things expoſed, and for the ſame Reaſon would $B =$ the Number of the q', and C the Number of r': But the Number of the p', which are in every Form of Combination, is $= \alpha$; therefore is $B - \alpha =$ to the Number of q'; alſo becauſe the Number of p' and q' together, which are in every Form of Combination, wherein there are q', is $= \alpha + \beta = b$; therefore is $C - b =$ to the Number of r', and ſo on, how many ſoever were the different Indices in any Form of Combination.

But (by *Lem.* 5th) the Number of the Combinations of the p', which are in the Things expoſed, whoſe Number is A, taken α and α, is

$= \frac{A \times A-1 \times A-2}{\alpha \times \alpha-1 \times \alpha-2}$ &c. continued to α places, and the Number of

the Combinations of the q', whoſe Number is $B - \alpha$, taken β and β, is

$= \frac{B-\alpha \times B-\alpha-1}{\beta \times \beta-1} \times \frac{B-\alpha-2}{\times \beta-2}$ &c. continued to β places, and

the Number of the Combinations of the r', whoſe Number is $C - b$,

taken γ and γ, is $= \frac{C-b \times C-b-1}{\gamma \times \gamma-1}$ &c. continued to γ places.

Q. E. D.

But

But every Combination, in one and the ſame Form, affords the ſame Number of Alternations: Therefore the Number of Alternations, in any one Form, is ſo many Times the Number of Combinations, as is the Number of Alternations in any one of theſe Combinations.

But (by *Lem.* 4th) the Number of Alternations in any of thoſe Combinations ſhall be

$n \times n\text{--}1 \times n\text{--}2 \times n\text{--}3 \times n\text{--}4 \times n\text{--}5 \times n\text{--}6 \times$ &c. continued to n Places.
$\overline{p \times p\text{--}1 \times p\text{--}2 \times \&c.}|^{\alpha} \times \overline{q \times q\text{--}2 \times \&c.}|^{\beta} \times 1 \times \overline{r\text{--}1 \times \&c.}|^{\gamma} \times$ each Series continued to $p\,q\,r$ &c. Places reſpectively. *Q. E. D.*

Now to make an Application of this general Rule, to thoſe particular Caſes which have already been conſidered by others, and which are contained in our 3d, 4th, 5th, and 6th *Lemma's*, and by us more generally demonſtrated; I ſay

If $n = m$, there can be but one Form of Combination, and but one Combination in that Form; and therefore the Number of Alternations $m \times m\text{--}1 \times m\text{--}2 \times m\text{--}3 \times m\text{--}4 \times$ &c. continued to m Places.

$\overline{p \times p\text{--}1 \times \&c.}|^{\alpha} \times \overline{q \times q\text{--}1 \times \&c.}|^{\beta} \times \overline{r \times \&c.}|^{\gamma} \times$ &c. each Series to $p\,q\,r$, &c. Places reſpectively, *i. e.* (if $p = 1$) $= m \times m - 1 \times m - 2 \times m - 3 \times m - 4 \times \&c.$ continued to m Places, which are the Caſes of the 4th and 3d *Lemma's*.

But if the Things expos'd are all different, and n be leſs than m, which is the Caſe of the 5th and 6th *Lemma's*, then alſo can there be but one Form of Combination, and it will be $A = m$ and $\alpha = n$, and the

whole Number of Combinations $= \frac{A \times A - 1 \times A - 2 \times \&c.}{\alpha \times \alpha - 1 \times \alpha - 2 \times \&c.}$ *i. e.*

$= \frac{m \times m - 1 \times m - 2 \times \&c.}{n \times n - 1 \times n - 2 \times \&c.}$ each Series continued to n Places, and therefore the Number of Alternations $= m \times m - 1 \times m - 2 \times \&c.$ continued to n Places.

But fully to illuſtrate this Theorem, which may ſeem ſomewhat too abſtracted, I ſhall ſubjoin one ſhort Example.

Example.] Let the Things expoſed be $a\,a\,a\,b\,b\,b\,c\,c$, or according to our Way of Notation $a^3\,b^3\,c^2$; 'Tis required to find the Number of their Combinations and Alternations taken 4 and 4.

Then (becauſe in the Things expoſed, there is no one Thing occurs more than thrice, nor more than three Things different from each other) will all the Forms of Combination, which the Things expoſed are capable of, be theſe,

viz. $\left\{\begin{matrix} 3 \cdot 1 \\ 2 \cdot 2 \\ 2 \cdot 1 \cdot 1 \end{matrix}\right\}$ Then

In

In the 1ſt Form will $p=3$, $q=1$, $\alpha=1$, $\beta=1$, $A=2$, $B=3$,
In the 2d Form will $p=2$, ——, $\alpha=2$, ——, $A=3$, ——
In the 3d Form will $p=2$, $q=1$, $\alpha=1$, $\beta=2$, $A=3$, $B=3$,

The Number of Combinations in the 1ſt Form $= \frac{A}{\alpha} \times \frac{B-\alpha}{\beta} = \frac{2}{1} \times \frac{2}{1} = 4$

The Number of Combinations in the 2d Form $= \frac{A \times A-1}{\alpha \times \alpha-1} = \frac{3 \times 2}{2 \times 1} = 3$

The Number of Combinations in the 3d Form $= \frac{A}{\alpha} \times \frac{B-\alpha \times B-\alpha-1}{\beta \times \beta-1} = \frac{2 \times 1}{2 \times 1} = 3$

And the whole Number of Combinations $= 10$

Alſo the Number of Alternations.

In the 1ſt Form $= 4 \times \frac{n \times n--1 \times n--2 \times n--3}{p \times p--1 \times p--2 \,|\, \alpha \times q\beta} = 4 \times \frac{4 \times 3 \times 2 \times 1}{3 \times 2 \times 1|} 1\times = 4 \times 4 = 16$

In the 2d Form $= 3 \times \frac{n \times n--1 \times n--2 \times n--3}{p \times p--1 \,|\, \alpha} = 4 \times \frac{4 \times 3 \times 2 \times 1}{2 \times 1|^{2}} = 3 \times 6 = 18$

In the 3d Form $= 3 \times \frac{n \times n--1 \times n--2 \times n--3}{p \times p--1 \,|\, \alpha \times q\beta} = 3 \times \frac{4 \times 3 \times 2 \times 1}{2 \times 1|^{1} \times 12} = 3 \times 12 = 36$

And the whole Number of Alternations $= 70$

Many are the Properties of this *Theorem* in common with others, as, To find the *Unciæ* of a Multinomial raiſed to any integer Power. To raiſe an infinite Series to an integer Power, though of an interrupted Order, without introducing any Thing immaterial, or which muſt afterwards be expunged, and many others. But then ſo many Terms of the Series muſt be taken in at firſt as ſhall ſerve to the Purpoſes of the intended Approximation, otherwiſe as often as it ſhall fall ſhort of that, the Operation muſt be begun *de novo*.

Many likewiſe are the Properties peculiar to this *Theorem*, and great Variety of Problems might be framed; and I ſcruple not to ſay, many may occur in Practice, which are ſolvable by this, and no other Method whatever.

Hence may be found the Number of Letters whereof the 24 Letters are capable, from one Letter in each Word, to any Number of Letters given.

Hence may be found the Number of all Numbers, to any given Number of Places, which may be produced from any Number of Figures given.

Hence also the Compass of a Musical Instrument being given, the Time and Number of the Bars, whereof each Tune shall consist, the Number of Tunes may be found which that Instrument is capable of.

To give an Instance of the prodigious Variety that there is in Musick, I have calculated the Number of Tunes in common Time, consisting of eight Bars each, which may be played on an Instrument of one Note Compass only, and it is this, *viz.* 27584. 270157. 013570. 368586. 999728. 299176. whereas the Changes on 24 Bells is but 620448. 401733. 239439. 360000, which is but

$\frac{1}{444588.604583}$ of the Number of Tunes, and yet Dr. *Wallis* in his *Algebra* demonstrates, could not be dispatched in 31557. 600000. 000000 Years.

If then the Instrument were of as many Notes Compass as any Instrument now in Use, how prodigiously must the Number of Tunes be encreased; the Calculation of which (though much more intricate and operose) would be equally attainable by our Theorem.

Equations Cubic and Biquadratic solv'd, &c. by Mr. J. Colson, n. 309. p. 2353.

XV. §. 1. Æquationis Cubicæ Universalis $\left.\begin{array}{r} x^3 = 3px^2 + 3qx + 2r, \\ -3p^2 + p^3 \\ -3pq \end{array}\right\}$

Radices tres sunt,

$$x = p + \sqrt[3]{r + \sqrt{r^2 - q^3}} + \sqrt[3]{r - \sqrt{r^2 - q^3}}$$

$$x = p - \frac{1 - \sqrt{-3}}{2} \times \sqrt[3]{r + \sqrt{r^2 - q^3}} - \frac{1 + \sqrt{-3}}{2} \times \sqrt[3]{r - \sqrt{r^2 - q^3}}$$

$$x = p - \frac{1 + \sqrt{-3}}{2} \times \sqrt[3]{r + \sqrt{r^2 - q^3}} - \frac{1 - \sqrt{-3}}{2} \times \sqrt[3]{r - \sqrt{r^2 - q^3}}$$

Vel ut Calculus Arithmeticus facilior at paratior evadat, si posueris Binomii irrationalis $r + \sqrt{r^2 - q^3}$ Radicem Cubicam esse $m + \sqrt{n}$, erunt ejusdem Æquationis Radices tres $x = p + 2m$, & $x = p - m \pm \sqrt{-3n}$.

Igitur data Æquatione quavis Cubica, inter ejus hujusque Æquationis Universalis terminos singulos instituenda est comparatio, quo pacto facillime invenientur ipsæ p, q, r; & hisce cognitis, innotescent Æqua-

tionis datæ Radices omnes. Hujus verò Solutionis Exempla ſint ſequentia in Numeris.

1. Æquationis Cubicæ $x^3 = 2x^2 + 3x + 4$ ſit Radix x indaganda. Erit primo juxta præſcriptum $3p = 2$, ſive $p = \frac{2}{3}$. Secundò $3q - (3p^2)\ \frac{4}{3} = 3$, ſive $q = \frac{13}{9}$. Tertiò $2r\ (+ \sqrt{p^2 - 3q} \times p) - \frac{70}{27} = 4$, ſive $r = \frac{89}{27}$, & $r^2 - q^3 = \frac{212}{27}$. Et propterea $x = \frac{2}{3} + \sqrt[3]{\frac{89}{27}} + \sqrt{\frac{212}{27}} + \sqrt[3]{\frac{89}{27}} - \sqrt{\frac{212}{27}}$. Reliquæ duæ Radices ſunt impoſſibiles.

2. In Æquatione $x^3 = 12x^2 - 41x + 42$, erit primò $3p = 12$, ſive $p = 4$. Secundò $3q - (3p^2)\ 48 = -41$, ſive $q = \frac{7}{8}$. Tertio $2r + (\sqrt{p^2 - 3q} \times p)\ 36 = 42$, ſive $r = 3$; Et inde $r^2 - q^3 = -\frac{100}{27}$. At Binomii ſurdi $3 + \sqrt{-\frac{100}{27}}$ $(= r + \sqrt{r^2 - q^3})$ Radix Cubica, per Methodos ex Arithmetica petendas extracta, eſt $-1 + \sqrt{-\frac{4}{3}}$ $(= m + \sqrt{n},)$ & proinde Radix $x = (p + 2m = 4 - 2 =)\ 2$, vel etiam $x = (p - m \pm \sqrt{-3n} = 4 + 1 \pm (\sqrt{4})\ 2 =)\ 7$ vel 3. Vel rurſus, ejuſdem Binomii $3 + \sqrt{-\frac{100}{27}}$. Radix alia Cubica (tres enim agnoſcit) eſt $\frac{3}{2} + \sqrt{-\frac{1}{12}}$ $(= m + \sqrt{n},)$ & proinde Radix $x = (p + 2m = 4 + 3 =)\ 7$, & etiam $x = (p - m \pm \sqrt{-3n} = 4 - \frac{3}{2} \pm (\sqrt{\frac{1}{4}})\ \frac{1}{2} = 3$ vel 2. Vel denuo, ejuſdem Binomii $3 + \sqrt{-}$

$\sqrt{-\frac{100}{27}}$ Radix Cubica tertia eſt $-\frac{1}{2}-\sqrt{-\frac{25}{12}}$, $(=m+\sqrt{n},)$ & proinde Radix $x=(p+2m=4-1=)$ 3, atque etiam $x=(p-m\pm\sqrt{-3n}=4+\frac{1}{2}\pm(\sqrt{\frac{25}{4}})\frac{5}{2}=)$ 7 vel 2.

3. In Æquatione $x^3=-15x^2-84x+100$, erit $p=-5$, $q=-3$, $r=135$; & Binomii $135+\sqrt{18252}$ Radix Cubica eſt $3+\sqrt{12}$. Igitur Radix $x=-5+6=1$, & $x=-5-3\pm\sqrt{-36}=-8\pm\sqrt{-36}$, impoſſibiles.

4. In Æquatione $x^3=34x-310x+1012$, erit $p=\frac{34}{3}$, $q=\frac{226}{9}$, $r=\frac{5536}{27}$; & Binomii $\frac{5536}{27}+\sqrt{\frac{707560}{27}}$ Radix Cubica eſt $\frac{16}{3}+\sqrt{\frac{10}{3}}$. Igitur Radix $x=\frac{34}{3}+\frac{32}{3}=22$, & $x=\frac{34}{3}-\frac{16}{3}\pm\sqrt{-10}=6\pm\sqrt{-10}$, impoſſibiles.

5. In Æquatione $x^3=28x^2+61x-4048$, erit $p=\frac{28}{3}$, $q=\frac{967}{9}$, $r=-\frac{25010}{27}$; & Binomii $-\frac{25010}{27}+\sqrt{-382347}$ Radix Cubica eſt $\frac{41}{6}+\sqrt{-\frac{243}{4}}$. Igitur $x=\frac{28}{3}+\frac{41}{3}=23$, & $x=\frac{28}{3}-\frac{41}{6}+(\sqrt{\frac{729}{4}})\frac{27}{2}=16$ vel -11.

6. In Æquatione $x^3=-x^2+166x-660$, erit $p=-\frac{1}{3}$, $q=\frac{499}{9}$, $r=-\frac{9658}{27}$; & Binomii $-\frac{9658}{27}+\sqrt{-\frac{1147205}{27}}$ Radix

Cubica

Cubica eſt $-\frac{22}{3}+\sqrt{=}\frac{5}{3}$. Igitur $x=-\frac{1}{3}-\frac{44}{3}=-15$, & $x=-\frac{1}{3}\frac{22}{3}\pm\sqrt{5}=7\pm\sqrt{5}$, irrationales.

7. In Æquatione $x^3=63x^2+99673x+9951705$, erit $p=21$, $q=\frac{100996}{3}$, $r=6031680$; & Binomii $6031680+\sqrt{-\frac{4788717504313 6}{27}}$

Radix Cubica eſt $183+\sqrt{-\frac{529}{3}}$. Igitur $x=21+366=387$, & $x=21-183\pm(\sqrt{529})\,23=-139$ vel 185.

Nec ſecus in cæteris procedendum: Inveſtigatur autem Theorema ad modum ſequentem. Pono Æquationis cujuſdam Cubicæ Radicem $z=a+b$, & cubicè multiplicando proveniet $z^3=(a^3+3a^2b+3ab^2+b^3=)\,a^3+3ab\times\overline{a+b}+b^3$. Jam loco ipſius $a+b$ valorem ejus z ſubſtituendo, fiet $z^3=3abz+a^3+b^3$, quæ eſt Æquatio Cubica ex Radice $z=a+b$ conſtructa, cui terminus ſecundus deeſt. Ut hæc verò ad formam magis commodam magiſque concinnam revocentur, ſumo Æquationem $z^3=3qz+2r$, quæ poſthac ipſius $z^3=3abz+a^3+b^3$ vices gerat. Igitur tranſmutatione hujus in illam, fiet primò $3q=3ab$, ſive $q^3=a^3b^3$; & ſecundò $2r=a^3+b^3$, ſive $2ra^3=(a^6+a^3b^3=)\,a^6+q^3$. Et ſoluta hac Æquatione quadratica, erit $a^3=r+\sqrt{r^2-q^3}$, & hinc $b^3=(2r-a^3=)\,r-\sqrt{r^2-q^3}$: Atque igitur tandem $a=\sqrt[3]{r+\sqrt{r^2-q^3}}$ & $b=\sqrt[3]{r-\sqrt{r^2-q^3}}$. Et propterea in Æquatione Cubica $z^3=3qz+2r$ erit Radix $z=(a+b=)$ $\sqrt[3]{r+\sqrt{r-q^3}}+\sqrt[3]{r-\sqrt{r-q^3}}$.

At verò hæc Radix reverà triplex eſt, pro triplici valore quem induere poteſt & $\sqrt[3]{r+\sqrt{r^2-q^3}}$ & $\sqrt[3]{r-\sqrt{r^2-q^3}}$. Cujuſvis enim quantitatis Radix Cubica triplex erit, & ipſius Unitatis Radix Cubica vel eſt 1, vel $-\frac{1}{2}+\frac{1}{2}\sqrt{-3}$, vel $-\frac{1}{2}-\frac{1}{2}\sqrt{-3}$: Atque id adeo, propterea quòd harum alicujus Cubus ſit Unitas. Igitur ſi $1\times\sqrt[3]{r+\sqrt{r^2-q^3}}$ aut $\sqrt[3]{r+\sqrt{r^2-q^3}}$ $(=\sqrt[3]{1\times r+\sqrt{r^2-q^3}}=\sqrt[3]{1}\times$

$\sqrt[3]{r+\sqrt{r^2-q^3}}$) Radicem aliquam [quam ſupra nominavimus $m+\sqrt{n}$, aut $1\times\overline{m+\sqrt{n}}$,] Cubi $r+\sqrt{r^2-q^3}$ deſignet; ipſæ $\frac{-1+\sqrt{-3}}{2}\times\sqrt[3]{r+\sqrt{r^2-q^3}}$ & $\frac{-1-\sqrt{-3}}{2}\times\sqrt[3]{r+\sqrt{r^2-q^3}}$ [i.e. $\frac{-1+\sqrt{-3}}{2}\times\overline{m+\sqrt{n}}$ & $\frac{-1-\sqrt{-3}}{2}\times\overline{m+\sqrt{n}}$] alias duas ejuſdem Cubi Radices deſignabunt. Similiter & $\sqrt[3]{r-\sqrt{r^2-q^3}}$, $\frac{-1+\sqrt{-3}}{2}\times\sqrt[3]{r-\sqrt{r^2-q^3}}$, & $\frac{-1-\sqrt{-3}}{2}\times\sqrt[3]{r-\sqrt{r^2-q^3}}$, [i.e. $m-\sqrt{n}$, $\frac{-1+\sqrt{-3}}{2}\times\overline{m-\sqrt{n}}$, $\frac{-1-\sqrt{-3}}{2}\times\overline{m-\sqrt{n}}$,] tres Cubicæ Radices erunt Apotomes $r-\sqrt{r^2-q^3}$. Atque has Radices debitè connectendo, fiet $z=\sqrt[3]{r+\sqrt{r^2-q^3}}+\sqrt[3]{r-\sqrt{r^2-q^3}}$, [i.e. $z=\overline{m+\sqrt{n}}+\overline{m-\sqrt{n}}=2m$,] $z=\frac{-1+\sqrt{-3}}{2}\times\sqrt[3]{r+\sqrt{r^2-q^3}}+\frac{-1-\sqrt{-3}}{2}\times\sqrt[3]{r-\sqrt{r^2-q^3}}$, [i.e. $z=\frac{-1+\sqrt{-3}}{2}\times\overline{m+\sqrt{n}}+\frac{-1-\sqrt{-3}}{2}\times\overline{m-\sqrt{n}}=-m+\sqrt{-3n}$,] & $z=\frac{-1-\sqrt{-3}}{2}\times\sqrt[3]{r+\sqrt{r^2-q^3}}+\frac{-1+\sqrt{-3}}{2}\times\sqrt[3]{r-\sqrt{r^2-q^3}}$ [i. e. $z=\frac{-1-\sqrt{-3}}{2}\times\overline{m+\sqrt{n}}+\frac{-1+\sqrt{-3}}{2}\times\overline{m-\sqrt{n}}=-m-\sqrt{-3n}$,] quæ tres erunt Radices Æquationis Cubicæ $z^3=3qz+2r$. Debitè autem connectuntur Radices iſtæ ad modum præcedentem, quippe quæ ſic connexæ, & more vulgari in ſe invicem continuè ductæ, Æquationem $x^3=3qz+2r$ reſtituunt. Denique fac $z=x-p$, & Æquatio

Æquatio fiet $x^3 - 3px^2 + 3p^2x - p^3 = 3qx - 3pq + 2r$, quæ univerſalis eſt, & cujus Radices evadunt ut ſupra fuerunt exhibitæ.

Hic obiter notatu dignum eſt, quod Æquationis Cubicæ cujuſcunque Radices omnes ſint poſſibiles & reales, quoties Binomii membrum irrationale $\sqrt{r^2 + q^3}$ impoſſibilitatem in ſe complectitur; hoc eſt, quoties q eſt quantitas affirmativa, & ſimul cubus ejus major eſt quadrato ex latere r. At ſi membrum iſtud $\sqrt{r^2 - q^3}$ ſit poſſibile, hoc eſt ſi q ſit quantitas negativa, aut etiam ſi affirmativæ cubus ſit minor quadrato ex latere r, tunc unicam tantùm agnoſcit Æquatio Radicem poſſibilem & realem, reliquæque duæ erunt impoſſibiles.

In hoc Theoremate ſit fiat $p = o$, hoc eſt, ſi deſit Æquationis terminus ſecundus, tunc deventum erit ad caſum Regularum quæ dicuntur *Cardani*, cujus ſolutio continetur in præcedentibus.

§. 2. Æquationis Biquadraticæ Univerſalis

$$x^4 = 4px^3 + 2qx^2 + 8rx + 4s,$$
$$\underline{-4p^2 \quad -4pq \quad -q^2}$$

Radices quatuor ſunt $x = p - a \pm \sqrt{p^2 + q - a^2 - \frac{2r}{a}}$,

$$\overline{\qquad\qquad\qquad\qquad}$$

& $x = p + a \pm \sqrt{p^2 + q - a^2 + \frac{2r}{a}}$, Ubi a^2 eſt Radix Æquationis

Cubicæ $a^6 = p^2 a^4 - 2pra^2 - r^2$.
$\quad\quad + q \quad - s$

Jam data Æquatione quavis Biquadratica, inter ejus hujuſque Æquationis Univerſalis terminos ſingulos inſtituenda eſt comparatio, quo pacto citiſſime invenientur ipſæ p, q, r, s; & hiſce cognitis, non latebit valor ipſius a, ex Theoremate ſuperiori inveniendus, & tum demum innoteſcent Æquationis datæ Radices omnes.

Huic Solutioni illuſtrandæ Exemplum unum aut alterum ſufficiat.

1. Æquationis Biquadraticæ $x^4 = 8x^3 + 83x^2 - 162x - 936$ ſint Radices extrahendæ. Erit primò juxta præſcriptum $4p = 8$, ſive $p = 2$. Secundò $2q - (4p^2)\,16 = 83$, ſive $q = \frac{99}{2}$. Tertiò $8r - (4pq)\,396 = -162$, ſive $r = \frac{117}{4}$. Quartò $4s - (q^2)\,\frac{9801}{4} = -936$, ſive $s = \frac{6057}{16}$. Hinc $p^2 + q = \frac{107}{2}$, $2pr + s = \frac{7929}{16}$, $r^2 = \frac{13689}{}$

$= \frac{13689}{19}$, & proinde $a^6 = \frac{107}{2} a^4 - \frac{7929}{16} a^2 + \frac{13689}{16}$. Jam ut Æquatio hæc aliquatenus Cubica in Radices ejus resolvatur, ad Theorema præcedens recurrendum est, in quo erit $p = \frac{107}{2}$, $q = \frac{22009}{144}$, $r = \frac{2903923}{1728}$, & $r^2 - q^3 = -\frac{11940075}{16}$. Atqui Binomii $\frac{2903923}{1728} + \sqrt{-\frac{11940075}{16}}$ Radix Cubica est $-\frac{53}{12} + \sqrt{-\frac{400}{3}}$ & propterea $a^2 = \frac{107}{6} - \frac{53}{6} = 9$, & etiam $a^2 = \frac{107}{6} + \frac{53}{12} \pm (\sqrt{400})\ 20 = \frac{169}{4}$ vel $\frac{9}{4}$: Vel quod perinde est, Æquationis præmissæ reverà Cubo-Cubicæ sex Radices sunt $a = \pm 3$, $a = \pm \frac{13}{2}$, & $a = \pm \frac{3}{2}$, quarum quævis indiscriminatim proposito nostro faciet satis. Puta si in præsenti casu fiat $a = 3$, erit juxta Theorema $x = (p - a \pm \sqrt{p^2 + q - a^2 - \frac{2r}{a}} = 2 - 3 \pm \sqrt{4 + \frac{99}{2} - 9 - \frac{39}{2}} = -1 \pm (\sqrt{25})\ 5 =)\ 4$ vel -6, & $x = (p + a \pm \sqrt{p^2 + q - a^2 + \frac{2r}{a}} = 2 + 3 \pm \sqrt{4 + \frac{99}{2} - 9 + \frac{39}{2}} = 5 \pm (\sqrt{64})\ 8 =)\ 13$ vel -3, quæ sunt Æquationis datæ Radices quatuor.

2. In Æquatione $x^4 = 20x^3 + 252x^2 - 6592x + 21312$, erit $p = 5$, $q = 176$, $r = -384$, & $s = 13072$. Hinc $p_2 + q = 201$, $2pr + s = 9232$, & $r^2 = 147456$; & inde $a^6 = 201\ a^4 - 9232\ a^2 + 147456$. Jam in Theoremate pro Cubicis erit $p = 67$, $q = \frac{4235}{3}$, &

$r =$

$r = 65219$; eritque Binomii $65219 + \sqrt{\frac{38889307072}{27}}$ Radix Cubica $\frac{77}{2} + \sqrt{\frac{847}{12}}$. Igitur $a^2 = 67 + 77 = 144$, ſive $a = 12$; & proinde $x = 5 - 12 \pm \sqrt{25 + 176 - 144 + 64} = -7 + (\sqrt{121})\ 11 = 4$ vel -18, & $x = 5 + 12 \pm \sqrt{25 + 176 - 144 - 64} = 17 \pm \sqrt{-7}$, impoſſibiles.

Hujus autem Theorematis Inventio eſt hujuſmodi: Ex duarum Æquationum Quadraticarum $z^2 + 2az - b = 0$, & $z^2 - 2az - c = 0$, in ſe invicem multiplicatione, Æquationem conficio Biquadraticam $z^4 = 4\overline{a^2 + b + c} \times z^2 + 2\overline{ac - 2ab} \times z - bc$, cui terminus ſecundus deeſt, quamque huic Æquationi $z^4 = ez^2 + fz + g$ ſtatuo æquipollere. Unde primo $4a^2 + b + c = e$ ſive $b = e - 4a^2 - c$. Secundò $2ac - 2ab = 4$, hoc eſt, $2ac - 2ae + 8a^3 + 2ac = f$, ſive $c = \frac{f}{4a} + \frac{e}{2} - 2a^2$, & inde $b = (e - 4a^2 - c =) - \frac{f}{4a} + \frac{e}{2} - 2a^2$. Tertiò $-bc = g$, ſive $-\frac{f^2}{16a^2} + \frac{e^2}{4} - 2ea^2 + 4a^4 = -g$, hoc eſt, $a^6 = \frac{1}{2}ea^4 - \frac{1}{4}ga^2 - \frac{1}{16}ea^2 + \frac{f^2}{64}$, quæ Æquatio quaſi Cubica eſt, ex Radice a^2 & notis vel aſſumptis e, f, g conflata. Ea verò Radix per Theorema ſuperius exhiberi poteſt, & eodem Calculo innoteſcent ipſæ b &c. At Æquationum $z^2 + 2az - b = 0$ & $z^2 - 2az - c = 0$ Radices ſunt $z = -a \pm \sqrt{a^2 + b}$ & $z = a + \sqrt{a^2 + c}$, ſive $= z - a + \sqrt{\frac{1}{2}e - a^2 - \frac{f}{4a}}$, & $z = a \pm \sqrt{\frac{1}{2}e - a^2 + \frac{f}{4a}}$, quæ proinde erunt Radices Æquationis $z^4 = ez^2 + fz + g$; cognita videlicet a vel a^2 ex Æquatione $a^6 = \frac{1}{2}ea^4 - \frac{1}{4}ga - \frac{1}{16}ea^2 + \frac{f^2}{64}$. Jam ut Æquatio iſta evadat univerſalis, & omnibus ſuis terminis inſtructa, fac $z = x - p$ eritque $x^4 - 4px^3 + 6p^2x^2 - 4p^3x + p^4 = ex^2 - 2pex + p^2e + fx - fp + g$, item & $x = p - a$

$\pm\sqrt{\frac{1}{2}e - a^2 - \frac{f}{4a}}$, & $x = p + a \pm \sqrt{\frac{1}{2}e - a^2 + \frac{f}{4a}}$. Tandem concinnitatis & compendii gratia, fac $e = 2q + 2p^2$ & $f = 8r$; tum $x^4 - 4p^2x^3 + 4p^2x^2 = 2qx^2 - 4p^2qx + 2p^2q + p^4 + 8rx - 8pr + g$, $x = p - a \pm \sqrt{p^2 + q - a^2 - \frac{r^2}{a}}$, $x = p + a + \sqrt{p^2 + q - a^2 + \frac{2r}{a}}$, & $a^6 = \overline{p^2 + q} \times a^4 - \frac{1}{4}g + \frac{1}{4}p^4 + \frac{1}{2}p^2q + \frac{1}{4}q^2 \times a^2 + r^2$. Denique fac $g = 4s - q^2 + 8pr - p^4 - 2p^2q$, & fiunt Æquationes præcedentes $x^4 = 4px^3 + 2qx^2 + 8rx + 4s$ & $a^6 = p^2a^4 - 2pra^2 + r^2$.

$$\begin{array}{llll} & -4p^2 & -4pq & -q^2 \\ +q & - & - & s \end{array}$$

Scilicet omnia evadunt ut ſupra ſunt poſita.

§. 3. Hactenus de Æquationum Cubicarum & Biquadraticarum Reſolutione Analytica: Quoniam autem earundem *Affectio Geometrica* per Parabolam vulgo tradi ſolet, & nonnullis in pretio eſt, ipſam συνοπτικῶς, & quidem univerſalius, non pigebit hîc exhibere.

Data Æquatione quavis vel Cubica vel Biquadratica, inſtituenda eſt comparatio inter terminos ejus, terminoſque reſpondentes hujus Æquationis

$$x^4 = \frac{2p}{q}x^3 + \frac{4pr}{q}x^2 + \frac{2p2}{q}x + p^2,$$

quo facto facile ſatis

$$\begin{array}{llll} & -4r & -4r^2 - \frac{2ps}{q} & -q^2 \\ & +2s & +4rs & -s^2 \\ & -1 & -2q & +t^2 \end{array}$$

eruentur ipſæ p, q, r, s, t; earum interim unâ aliquâ utcunque pro lubitu aſſumptâ. Tum in Parabola quavis data AVB, cujus Vertex principalis V, Axis VS, & Axi perpendicularis VT: capiatur $VS = p$ verſus interiora Parabolæ, & in Angulo SVT inſcribatur $ST = q$, quæ producta Parabolam ſecet in punctis binis N & O. Biſecetur ON in M, & per M agatur MA Axi parallela & parabolæ occurrens in A. Ipſi ON parallela ducatur AL, ut ſi AL Latus rectum Parabolæ ad Diametrum AM, ſitque hæc eadem unitas. In AL (utrinque ſi opus eſt producta) capiatur $AG = r$, & a puncto G ducatur GR Axi parallela, & quæ Parabolam ſecet in B, a quo capiatur $BR = s$. A noviſſime invento puncto R ducatur RE ipſi VT parallela & æqualis, quæ ſiniſtram verſus jaceat reſpectu ipſius R ſi q ſit quantitas affirmativa, adverſus

Fig. 31.

verſus dextram ſi q ſit negativa. Atque idem de ipſis AG & BR intelligatur, quæ ad contrarias itidem partes duci debent, ſi modo valores ipſarum r & s prodeant negativi. Denique Centro E & Radio $EC = t$ deſcribatur Circulus $CKkc$, qui Parabolam in totidem ſecabit punctis, quot ſunt Æquationis datæ radices reales. Etenim a punctis iſtis CK, &c. ducantur CP, $k\Pi$, &c. ipſi ST parallelæ, & ad rectam GR (ſi opus eſt productam) terminatæ, eritque harum quævis x, ſeu Æquationis datæ radix quæſita; eæ ſcilicet ad dextram jacentes erunt Radices affirmativæ, quæ vero ad ſiniſtram ſunt poſitæ erunt radices negativæ. Punctum contactûs, ſi quod fuerit, hic ſumitur pro interſectionis punctis duobus ad invicem viciniſſimis.

Inter Æquationes Cubicas & Biquadraticas ita conſtructas hoc tantum intercedit diſcriminis, quod in prioribus ob terminum ultimum in præcedente Æquatione deficientem, ſemper ſit $p^2 - q^2 - s^2 + t = 0$, ſive $t = \sqrt{s^2 + q^2 - p^2}$. Igitur Centro E & Radio EC $(= \sqrt{BRq + (ERq)\,ST q - VSq})$ deſcripto Circulo $CKkc$, Radicum una CP in priori conſtructione in nihilum abit.

Hæc autem demonſtrantur ad modum ſequentem; manentibus jam conſtructis, & producta CP, ſi opus eſt, donec ſecet AM in H, erit CH ordinata Parabolæ ad Diametrum AH, & proinde $CHq = AL \times AH = AH$, ob $AL = 1$. At $CH = CP + AG$, & $AH = GB + BP$, & propterea $CPq + 2AG \times CP + AGq = GB + BP$; ſed ob naturam Parabolæ erit $AGq = GB$, unde $2CPq + 2AG \times CP = BP$. Jam a puncto C ad ipſam BP demittatur normalis sCD, quæ occurrat etiam ipſi EI, ad BP actæ parallelæ, in puncto I. Propter ſimilia Triangula CDP & TVS, erit $DP = \frac{VS \times CP}{ST}$ & $CD = \frac{VT \times CP}{ST}$, & proinde $CPq +$

$2AG \times CP = BP = DP + DB = \frac{VS \times CP}{ST} + BR - IE$; five

$CPq + 2AG \times CP - \frac{VS}{ST} CP - BR = -IE$. Aſt $IEq = CEq -$

$CIq = CEq - CDq - VTq - 2CD \times VI = CEq - \frac{VTq \times CPq}{STq}$

$- VTq - \frac{2VTq \times CP}{ST} = (\text{ob } VTq = STq - SVq)\, CEq - CPq + \frac{SVq}{STq}$

$CPq - STq + SVq - 2ST \times CP + \frac{2SVq}{ST} CP$, quæ igitur æqualis erit

Quadrato ex Latere $CPq + 2AG \times CP - \frac{VS}{ST} CP - BR$. Atque hæc Æquatio ad terminos p, q, r, s, t, revocata ipsissima fit Æquatio proposita.

Hinc liquet, quòd eadem quævis Æquatio Biquadratica innumeras per Parabolam constructiones sortiri possit, pro indefinito valore quantitatis istius, quam ad arbitrium assumi posse jam diximus. Sed casus est simplicissimus faciendo $VS = p = 0$, & migrat constructio, si rem ipsam spectes, in vulgarem istam, in qua Radicum repræsentatrices rectæ CP, &c. sunt ad Axem perpendiculares. Æquatio autem fit $x^4 = -4rx^3 - 4r^2x^2 + 4rsx - q^2$,
$+2s \quad -2q \quad -s^2$
$-1 \quad +t^2$
quæ facilè construitur ut supra.

§. 4. Sed ne Parabolæ descriptio Organica difficilis nimium videatur, in promptu est Artificium quoddam Mechanicum, ope Fili penduli pondere instructi peractum, cujus auxilio quam exactissime & facillime Æquatio novissima construi potest, & proinde Æquationum quarumcunque Cubicarum & Biquadraticarum Radices inveniri; idque sine ullo linearum ductu nisi Rectarum & Circuli. Constructio autem quam appellare libet *Mechanicam*, est ad hunc modum.

Fig. 32. Contra Parietem erectum, vel planum aliud quodvis Horizonti perpendiculare, ad punctum aliquod F suspendatur filum tenuissimum & flexile FP; pondere quovis P ad extremitatem P appenso. In hoc filo notetur punctum aliquod N, à puncto suspensionis F satis remotum, vel filo parvulus, si id mavis, innectatur Nodus N. Et sumpta utcunque NO pro Unitate, ad punctum medium A ducatur (in plano prædicto) recta $A\mathcal{Q}$ Horizonti parallela, & utrinque quantum satis producta. Hisce generaliter paratis, pro particulari jam applicatione fac $A\mathcal{Q} = r$; ipsis q, r, s, t, ut sæpius inculcatum, vel Arithmeticè vel Geometricè, pro datæ cujusvis Æquationis exigentia, in Æquatione novissima prius determinatis. Tunc Acu vel Stylo tenuissimo, aut etiam cuspide Circini admodum gracili, flectatur filum a loco suo ad punctum quoddam B, ita ut Punctum N cadat in novissime invento puncto $\mathcal{Q}$. In $B\mathcal{Q}$ ab isto B capiatur $BR = s$, & in R ad ipsam BR perpendicularis erigatur $ER = q$. Verum enimvero istæ $A\mathcal{Q}$, BR, RE ad contrarias partes ab earum initiis cadere debent, si forte valores ipsarum r, s, q prodeant negativi. Denique in puncto invento E figatur Circini crus unum, &, ad distantiam $EZ = t$ extentum, agatur crus alterum in orbem, secumque circumducat filum FZP. Hæc fili circulatione pondus P nunc ascendet nunc descendet motu reciproco, ut & Nodus N nunc supra rectam $A\mathcal{Q}$ extabit, nunc vero infra eandem deprimetur. Quoties autem reperietur Nodus ille N in ipsa $A\mathcal{Q}$, puta in punctis D, $d\Delta$, δ abscindet is rectas $D\mathcal{Q}$, $d\mathcal{Q}$, $\Delta\mathcal{Q}$, $\delta\mathcal{Q}$, quæ erunt Æquationis datæ Radices reales; hæ nempe ad dextram erunt

Radices affirmativæ, illæ vero ad ſiniſtram Radices negativæ. Demonſtratio eſt manifeſta ex præcedentibus, habita tantum ratione Parabolæ per puncta $BC\,c\,k\,K$ tranſeuntis. Nam poſito F foco Parabolæ (cujus diſtantia a Vertice eſt $\frac{1}{4}\,ON$) notum eſt, quod lineæ omnes ut $FB + B2$, $FC + CD$, &c. eandem ubique conficiant ſummam.

Atque ex his principiis hic poſitis proclive erit Inſtrumentum haud inconcinnum, & quantumvis accuratum fabricari, cujus beneficio hujuſmodi Æquationum quarumcunque Radices nullo fere negotio inveniri poſſunt, & præ oculis exhiberi.

Equations of the 3d, 5th, 7th, 9th, &c. *Powers ſolv'd Analytically by Mr.* Abr. de Moivre, n. 309. p. 2368.

XVI. Sit n Numerus quicunque, y quantitas incognita, ſive Æquationis Radix quæſita, ſitque a quantitas quævis omnino cognita, ſive ut vocant Homogeneum Comparationis; atque horum inter ſe relatio exprimatur per Æquationem.

$$ny + \frac{nn-1}{2\times 3}\,ny^3 + \frac{nn-1}{2\times 3}\times\frac{nn-9}{4\times 5}\,ny^5 + \frac{nn-1}{2\times 3}\times\frac{nn-9}{4\times 5} + \frac{nn-25}{6\times 7}\,ny^7, \text{ &c.} = a.$$

Ex hujus ſeriei natura manifeſtum eſt, quod ſi n ſumatur numerus aliquis impar (integer ſcilicet, nec refert utrum ſit affirmativus vel negativus) tunc ſeries ſponte ſua terminabitur, & Æquatio fit una ex ſupra præfinitis, cujus Radix eſt

$$(1)\quad y = \tfrac{1}{2}\sqrt[n]{\sqrt{1+aa}+a} - \frac{\frac{1}{2}}{\sqrt[n]{\sqrt{1+aa}+a}}$$

$$\text{vel } (2)\quad y = \tfrac{1}{2}\sqrt[n]{\sqrt{1+aa}+a} - \tfrac{1}{2}\sqrt[n]{\sqrt{1+aa}+a}$$

$$\text{vel } (3)\quad y = \frac{\frac{1}{2}}{\sqrt[n]{\sqrt{1+aa}-a}} - \tfrac{1}{2}\sqrt[n]{\sqrt{1+aa}-a}$$

vel

vel (4) $y = \frac{\frac{1}{2}}{\sqrt[n]{\sqrt{1+aa}-a}} - \frac{\frac{1}{2}}{\sqrt[n]{\sqrt{1+aa}-a}}$

Exempli gratia, fit hujus Æquationis poteſtatis quintæ $5y+20y^3+16y^5=4$ Radix invenienda, quo in caſu erit $n=5$ & $a=4$.

Radix juxta formam primam erit $y = \frac{1}{2}\sqrt[5]{\sqrt{17}+4} - \frac{\frac{1}{2}}{\sqrt[5]{\sqrt{17}+4}}$

quæ in numeris vulgaribus expeditiſſimè explicari poteſt ad hunc modum. Eſt $\sqrt{17}+4=8.1231$, cujus Logarithmus 0.9097164, & hujus pars quinta 0.1819433, huic reſpondens numerus eſt $1.5203 = \sqrt[5]{\sqrt{17}+4}$, Ipſius vero 0.1819433 Complementum Arithmeticum eſt 9.8180567, cui reſpondet numerus $0.6577 = \frac{1}{\sqrt[5]{\sqrt{17}+4}}$. Igitur horum numerorum ſemidifferentia $0.4313 = y$.

Obſervandum eſt quod loco Radicis generalis, non incommode ſumeretur $y = \frac{1}{2}\sqrt[n]{2a} - \frac{\frac{1}{2}}{\sqrt[n]{2a}}$, ſi quando numerus a reſpectu unitatis, ſit ſatis magnus, ut ſi Æquatio fuerit $5y+20y^3+16y^5=682$; erit Log. $2a=3.1348143$, cujus pars quinta 0.6269628, & huic reſpondens numerus 4.236. Complementi autem Arithmetici 9.3730372 numerus eſt 0.236 & horum numerorum ſemidifferentia $2=y$.

Atqui præterea, ſi in Æquatione præcedenti ſigna alternatim ſint affirmantia & negantia, vel quod eodem redit, ſi ſeries obvenerit hujus modi.

$$ny+\frac{1-nn}{2\times3}ny^3+\frac{1-nn}{2\times3}\times\frac{9-nn}{4\times5}ny^5+\frac{1-nn}{2\times3}\times\frac{9-nn}{4\times5}\times\frac{25-nn}{6\times7}ny^7, \text{ &c.} = a.$$

Erit hujus Radix

$$(1)\ y = \tfrac{1}{2}\sqrt[n]{a+\sqrt{aa-1}} + \frac{\frac{1}{2}}{\sqrt[n]{a-\sqrt{aa-1}}}$$

$$\text{vel } (2)\ y = \tfrac{1}{2}\sqrt[n]{a+\sqrt{aa-1}} + \tfrac{1}{2}\sqrt[n]{a-\sqrt{aa-1}}$$

$$\text{vel } (3)\ y = \frac{\frac{1}{2}}{\sqrt[n]{a-\sqrt{aa-1}}} + \tfrac{1}{2}\sqrt[n]{a-\sqrt{aa-1}}$$

$$\text{vel } (4)\ y = \frac{\frac{1}{2}}{\sqrt[n]{a-\sqrt{aa-1}}} + \frac{\frac{1}{2}}{\sqrt[n]{a+\sqrt{aa-1}}}$$

Hic autem notandum, quod ſi $\frac{n-1}{2}$ numerus extiterit impar, Radicis inventæ ſignum in eo contrarium permutandum eſt.

Proponatur Æquatio $5y - 20y^3 + 16y^5 = 6$, unde $n = 5$ & $a = 6$,

$$\text{Erit Radix} = \tfrac{1}{2}\sqrt[5]{6+\sqrt{35}} + \frac{\frac{1}{2}}{\sqrt[5]{6+\sqrt{35}}}$$

Vel quoniam $6 + \sqrt{35} = 11.916$, erit hujus Logarithmus 1.0761304 & ejus pars quinta 0.2152561, Complementum vero Arithmeticum 9.7847439. Horum Logarithmorum numeri ſunt 1.6415 & 0.6091 reſpectivè, quorum ſemiſumma 1.1253 $= y$.

Verum ſi acciderit ut a ſit minor unitate, tunc Radicis forma ſecunda, ut quæ propoſito eſt magis conveniens, præ reliquis ſeligenda eſt.

Sic ſi Æquatio fuerit $5y - 20y^3 + 16y^5 = \frac{61}{64}$, erit $y = \tfrac{1}{2}\sqrt[5]{\frac{61}{64}+\sqrt{\frac{-375}{4096}}}$

+

$+\frac{1}{2}\sqrt[5]{\frac{61}{64}-\sqrt{\frac{-375}{4096}}}$. Et quidem ſi Binomialium Radix quintan ullo pacto extrahi queat, prodibit Radix proba & poſſibilis, etſi expreſſio ipſa impoſſibilitatem mentiatur. Binomialis vero $\frac{61}{64}+\sqrt{\frac{-375}{4096}}$ Radix quintana eſt $\frac{1}{4}+\frac{1}{4}+\sqrt{-15}$, & Binomialis $\frac{61}{64}-\sqrt{\frac{-375}{4096}}$ Radix itidem quintana eſt $\frac{1}{4}-\frac{1}{4}\sqrt{-15}$, quorum Binomialium ſemiſumma $=\frac{1}{4}=y$.

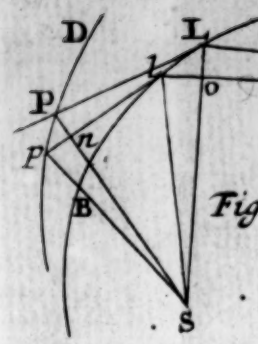
Si autem extractio iſta vel non peragi poſſet, vel etiam difficilior videretur, res ubique confici poteſt per Tabulam ſinuum naturalium ad modum ſequentem.

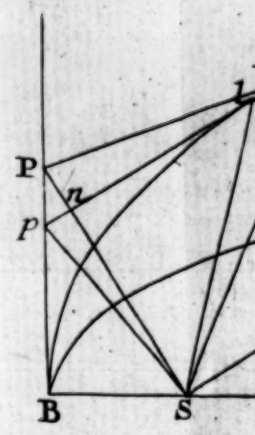
Ad Radium 1 ſit $a=\frac{61}{64}=0.95112$ ſinus arcus cujuſdam, qui proinde erit 72° : 23′ cujus pars quinta (eo quod $n=5$) eſt 14° : 28′; hujus ſinus $0.24981=\frac{1}{4}$ proxime. Nec ſecus procedendum in Æquationibus graduum ſuperiorum.

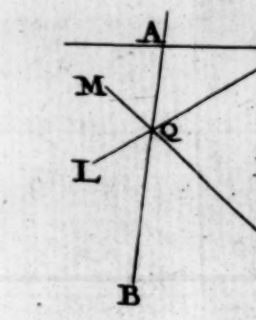
The Method of Approximating, *in Extracting the* Roots *of* Equations *in Numbers*, improv'd *by Dr.* B. Taylor, n. 352. p. 610. † Vid. *ſup.* V. I. C. I. S. XX.

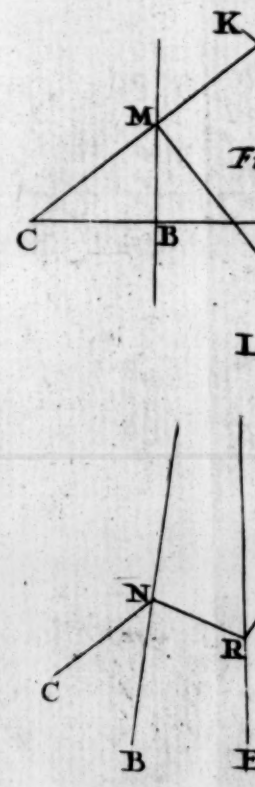
XVII. Dr. *Halley* has publiſh'd † a very compendious and uſeful Method of extracting the Roots of adfected Equations of the common Form in Numbers. This Method proceeds by aſſuming the Root deſired nearly true to one or two Places in Decimals (which is done by a Geometrical Conſtruction, or by ſome other convenient Way) and correcting the Aſſumption by comparing the Difference between the true Root and the aſſumed, by means of a new Equation whoſe Root is that Difference, and which he ſhews how to form from the Equation propoſed, by Subſtitution of the Value of the Root ſought, partly in known and partly in unknown Terms.

In doing this he makes uſe of a Table of Products (which he calls *Speculum Analyticum*,) by which he computes the Coefficients in the new Equation for finding the Difference mentioned. This Table, I obſerved, was formed in the ſame manner from the Equation propos'd, as the Fluxions are, taking the Root ſought for the only flowing Quantity, its Fluxion for Unity, and after every Operation dividing the Product ſucceſſively by the Numbers 1, 2, 3, 4, &c. Hence I ſoon found that this Method might eaſily and naturally be drawn from *Cor.* 2. *Prop.* 7. of my *Methodus Incrementorum*, and that it was capable of a further Degree of Generality, it being applicable, not only to Equations of the common Form, (*viz.* ſuch as conſiſt of Terms wherein the Powers of the Root ſought are poſitive and integral, without any radical Sign) but alſo to all Expreſſions in general, wherein any Thing is propoſed as given which by any known Method might be









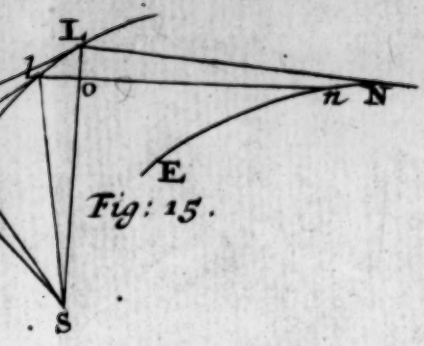
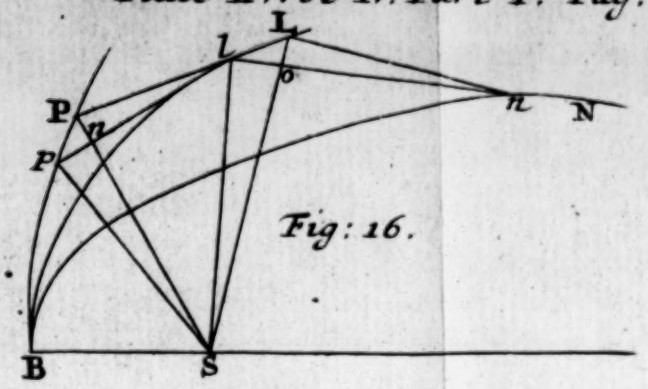


Fig: 15.



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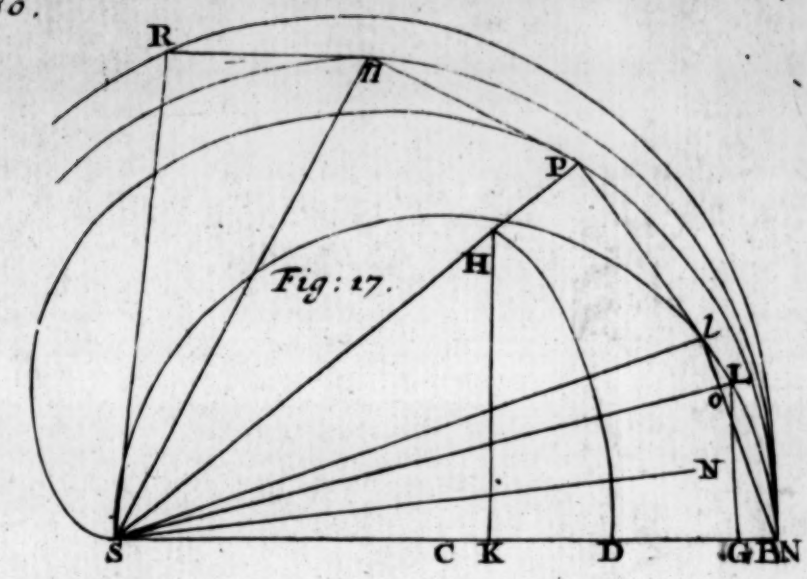

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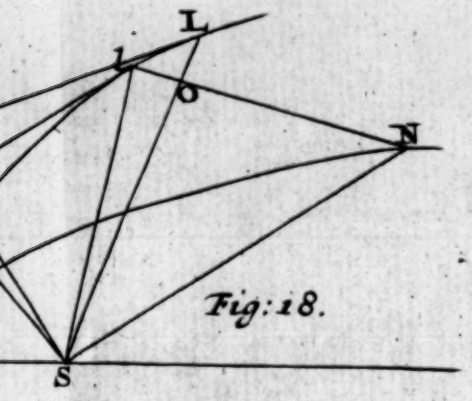

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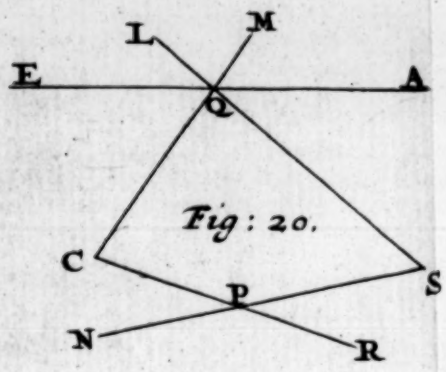

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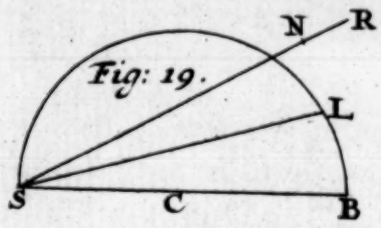

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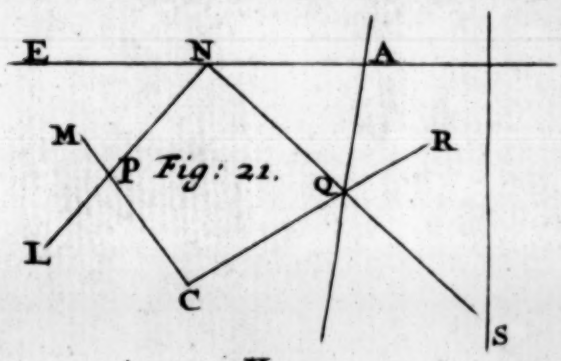

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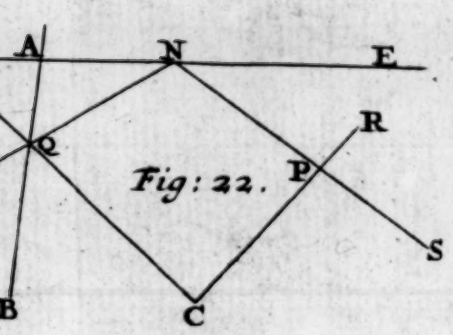

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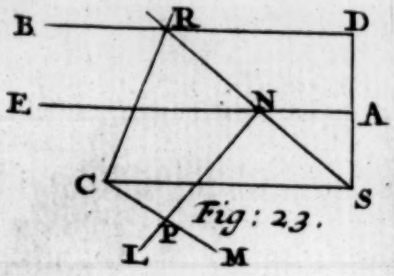

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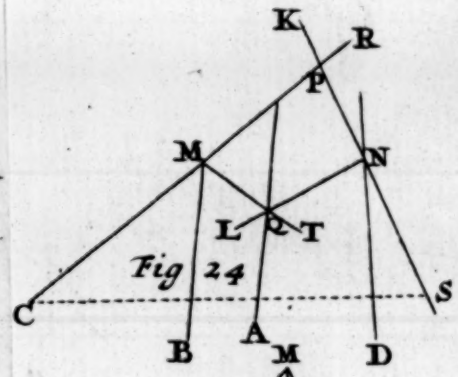
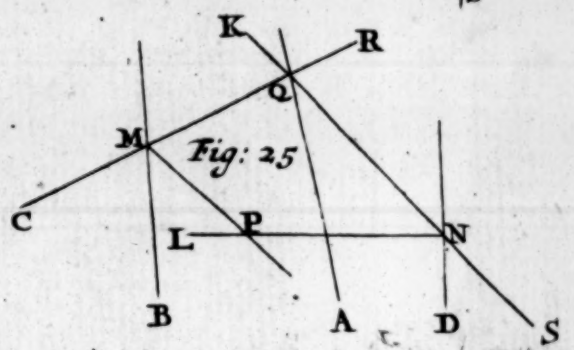


Fig 24



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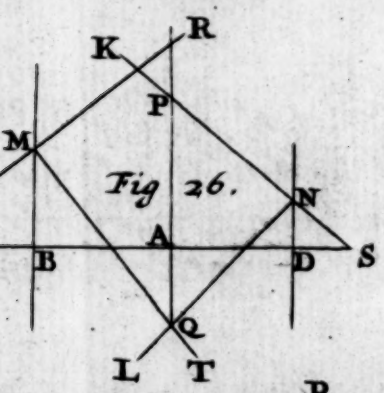

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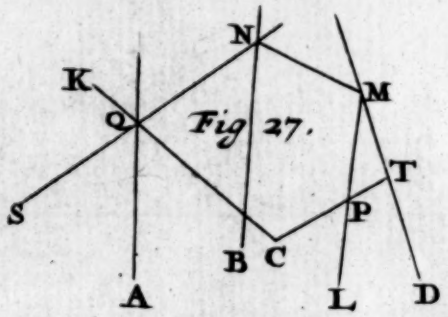
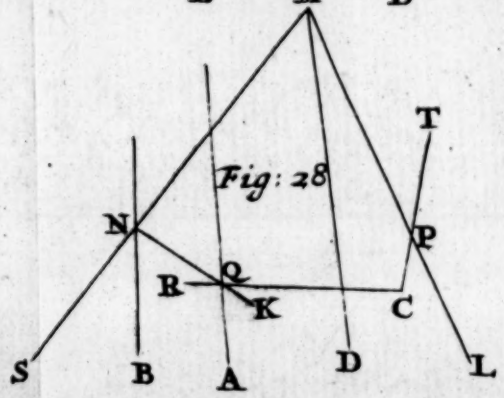


Fig 27.



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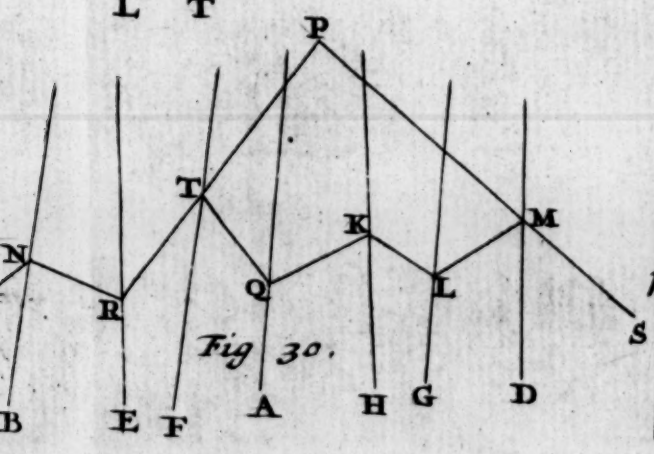


Fig 30.

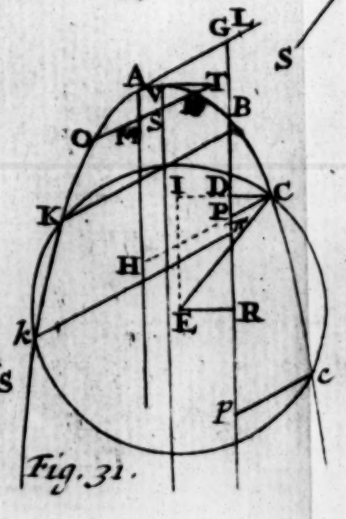
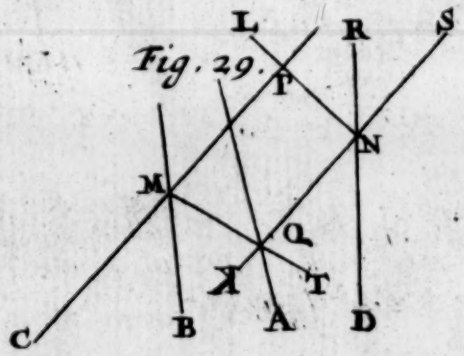


Fig. 31.



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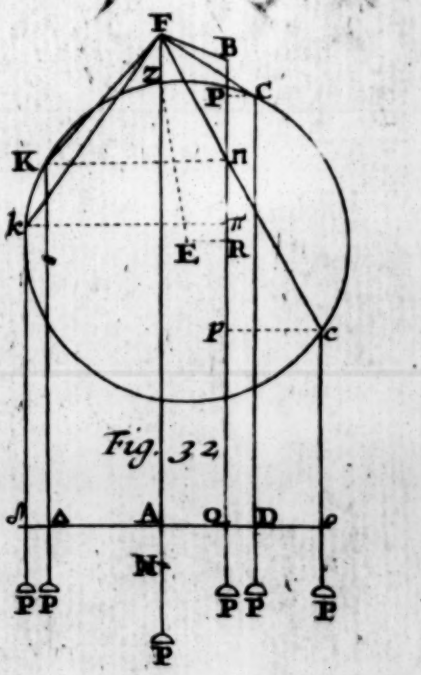

Fig. 32

be computed; if *vice versâ*, the Root were conſidered as given: Such as are all radical Expreſſions of Binomials, Trinomials, or of any other Nomial, which may be computed by the Root given, at leaſt by Logarithms, whatever be the Index of the Power of that Nomial; as likewiſe Expreſſions of Logarithms, of Arches by the Sines or Tangents, of Areas of Curves by the *Abſciſſas* or any other Fluents or Roots of fluxional Equations, *&c.*

For the ſake of this great Generality, it may not be improper to ſhew how this Method is derived from the foreſaid *Corollary*; therefore z and x being two flowing Quantities (whoſe Relation to one another may be expreſſed by any Equation whatſoever) by this *Corollary*, while

z by flowing uniformly becomes $z+v$, x will become $x+\frac{\dot{x}}{1\,.\,\dot{z}}v$

$+\frac{\ddot{x}}{1\,.\,2\dot{z}^2}v^2+\frac{\dddot{x}}{1\,.\,2\,.\,3\dot{z}^3}v^3+$ &c. or $x\frac{\dot{x}v}{1}+\frac{\ddot{x}v^2}{1\times 2}+\frac{\dddot{x}v^3}{1\,.\,2\,.\,3}+$ &c.

for $\dot{z}$ putting 1.

Hence if y be the Root of any Expreſſion formed of y and known Quantities, and ſuppoſed equal to nothing, and z be a Part of y, and x be formed of z and the known Quantities, in the ſame Manner as the Expreſſion made equal to nothing is formed of y; and let y be equal to $z+v$: the Difference v will be found by extracting the Root of

this Expreſſion $x+\frac{\dot{x}v}{1}+\frac{\ddot{x}v^2}{1\,.\,2}+\frac{\dddot{x}v^3}{1\,.\,2\,.\,3}+$ &c. $=0$. For in this Caſe z being become $z+v=y$, x, which is now become $x+\dot{x}v+\frac{\ddot{x}v^2}{2}$ + &c. muſt become equal to nothing.

The Root v in the Equation $x+\frac{\dot{x}v}{1}+\frac{\ddot{x}v^2}{1\,.\,2}+\frac{\dddot{x}v^3}{1\,.\,2\,.\,3}+$ &c. $=0$,

is to be found upon the Suppoſition of its being very ſmall with reſpect to z, (as it muſt be, if z be taken tolerably exact) by which Means

the Terms $\frac{\dddot{x}v^3}{1\,.\,2\,.\,3}+\frac{\ddddot{x}v^4}{1\,.\,2\,.\,3\,.\,4}+$ &c. may be neglected, upon ac-

count of their Smallneſs with reſpect to the other Terms, ſo as to leave the Equation $x + \frac{\dot{x}\,v}{1} + \frac{\ddot{x}\,v^2}{1\,.\,2} = 0$, for finding the firſt Approximation of v.

By extracting the Root of this Equation, we have

$v = \sqrt{\frac{\dot{x}^2}{\ddot{x}^2} - \frac{2x}{\ddot{x}}} - \frac{\dot{x}}{\ddot{x}}$. That is,

Firſt, $\sqrt{\frac{\dot{x}^2}{\ddot{x}^2} - \frac{2x}{\ddot{x}}} - \frac{\dot{x}}{\ddot{x}}$, if $x + \dot{x}v + \frac{\ddot{x}v^2}{2} = 0$.

Second, $\sqrt{\frac{\dot{x}^2}{\ddot{x}^2} + \frac{2x}{\ddot{x}}} - \frac{\dot{x}}{\ddot{x}}$, if $-x + \dot{x}v + \frac{\ddot{x}v^2}{2} = 0$.

Third, $\frac{\dot{x}}{\ddot{x}} - \sqrt{\frac{\dot{x}^2}{\ddot{x}^2} - \frac{2x}{\ddot{x}}}$, if $x - \dot{x}v + \frac{\ddot{x}v^2}{2}$, &c. $= 0$.

Fourth, $\frac{\dot{x}}{\ddot{x}} - \sqrt{\frac{\dot{x}^2}{\ddot{x}^2} - \frac{2x}{\ddot{x}}}$, if $-x - \dot{x}v + \frac{\ddot{x}v^2}{2}$, &c. $= 0$.

This Approximation gives v exact to twice as many Places as there are true Figures in z, and therefore trebles the Number of true Figures in the Expreſſion of y by $z + v$, which may be taken for a new Value of z, for computing a ſecond v, ſeeking other Values of $\dot{x}$, $\ddot{x}$, $\dddot{x}$, &c. Though when z is tolerably exact (which it may be eſteemed when it contains two or three or more true Figures in the Value of y, according to the Number of Figures the Root is propoſed to be computed to,) the Calculation may be reſtor'd without ſo much Trouble, only by taking $\sqrt{\frac{\dot{x}^2}{\ddot{x}^2} \pm \frac{2x}{\ddot{x}} - \frac{2\dddot{x}}{2\,.\,3\,\ddot{x}}v^3 - \frac{2\ddddot{x}}{1\,.\,2\,.\,3\,4\ddot{x}}v^4}$, &c. inſtead of $\sqrt{\frac{\dot{x}^2}{\ddot{x}^2} \pm \frac{2x}{\ddot{x}}}$ taking every Time for v its Value laſt computed.

From

From the ſame Equation $x + \dot{x}v + \frac{\ddot{x}v^2}{2} + \frac{\dddot{x}v^3}{1.2.3} + \&c. = 0$,

may be gather'd alſo a rational Form, *viz.* $v = \frac{-x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}$ For neglect-

ing the Terms $\frac{\dddot{x}v^3}{1.2.3}$, &c. we have $v = \frac{-x}{\dot{x} + \frac{\ddot{x}}{2}v}$ which is nearly

$= \frac{-x}{\dot{x}}$. Therefore in the Diviſor inſtead of v writing $\frac{-x}{\dot{x}}$ we have

more exactly $v = \frac{-x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}$, that is

1. $\frac{-x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}$, when $x + \dot{x}v + \frac{\ddot{x}v^2}{2}$ &c. $= 0$.

2. $\frac{x}{\dot{x} + \frac{\ddot{x}x}{2\dot{x}}}$, when $-x + \dot{x}v + \frac{\ddot{x}v^2}{2}$ &c. $= 0$.

3. $\frac{x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}$, when $x - \dot{x}v + \frac{\ddot{x}v^2}{2}$ &c. $= 0$.

4. $\frac{-x}{\dot{x} + \frac{\ddot{x}x}{2\dot{x}}}$, when $-x - \dot{x}v + \frac{\ddot{x}v^2}{2}$ &c. $= 0$.

This *Formula* will alſo triplicate the Number of true Figures in z. And the Calculation may be repeated, after every Operation, taking

for a Diviſor $\dot{x} \pm \frac{\ddot{x}}{2} v + \frac{\dddot{x} v^2}{1 \cdot 2 \cdot 3} + \frac{\ddddot{x} v^3}{1 \cdot 2 \cdot 3 \cdot 4} + \&c.$ inſtead of

$x + \frac{\ddot{x}\, x}{2\, \dot{x}}$.

Dr. *Halley* has fully explained the Manner of uſing both theſe *Formula's* in Equations of the common Form; wherefore I ſhall be the ſhorter in explaining two or three Examples of another ſort.

Ex. 1. Let it be propoſed to find the Root of this Equation $\overline{y^2 + 1}|^{\sqrt{2}} + y - 16 = 0$. In this Caſe, for y writing z, and for o writing x, we have $\overline{z^2 + 1}|^{\sqrt{2}} + z - 16 = x$. Whence by taking the Fluxions, we have $\dot{x} = 2\sqrt{2} \times z \times \overline{z^2 + 1}|^{\sqrt{2}-1} + 1$, and $\ddot{x} = 2\sqrt{2} \times \overline{8 - 4\sqrt{2}\, z^2} \times \overline{z^2 + 1}|^{\sqrt{2}-2}$. For finding the firſt Figures of the Root y, for $\sqrt{2}$ take $\frac{3}{2}$, and we have the Equation $\overline{y^2 + 1}|^{\frac{3}{2}} + y - 16 = 0$, which being expanded gives $y^6 + 3y^4 + 2y^2 + 32y - 255 = 0$.

By this Equation I find that for the firſt Suppoſition we may take $z = 2$. Therefore in order to find v, let us now make $\sqrt{2} = \frac{7}{5}$, (which is nearer than before) and we have $x = \overline{z^2 + 1}|^{\frac{7}{5}} + z - 16 = \overline{z^2 + 1}|^{\frac{7}{5}} - 14 = 5^{\frac{7}{5}} - 14 = -4,48$; $\dot{x} = 10,66$; $\ddot{x} = 4,72$. Whence by the ſecond rational Form $v = \cfrac{4,48}{10,66 + \cfrac{4,72 \times 4,48}{2 \times 10,66}} = 0,38$;

which muſt be too big, becauſe $\frac{7}{5} < \sqrt{2}$, and therefore will require a larger Value of y to exhauſt the Equation, than where $\sqrt{2}$ is exact. For the ſecond Suppoſition therefore, let us take $z = 2,3$, and make $\sqrt{2} = 1,4142136$, and by help of the Logarithms we ſhall have $\overline{z^2 + 1}|^{\sqrt{2}} = 13,47294$, whence $x = -0,22706$; $\dot{x} = 14,93429$, and $\ddot{x} = 5,18419$. Hence by the 2*d* irrational *Formula*

$v =$

$v = \sqrt{\frac{14,93429^2}{5,18419^2} + \frac{0,45412}{5,18419}} - \frac{14,93429}{5,18419} = 0,0516$, which gives $y = z + v = 2,31516$, which is true to six Places. If you desire it more exact than to the Extent of the Tables of Logarithms, taking $z = 2,31516$ for the next Supposition, the Calculation must be repeated by computing of $\overline{zz+1}\,|^{\nu}$ to a sufficient Number of Places; which must be done by the Binomial Series, or by making a Logarithm on Purpose, true to as many Places as are necessary.

Ex. 2. For another Example, let it be required to find the Number whose Logarithm is 0,29, supposing we had no other Table of Logarithms, but Mr. *Sharp*'s of 200 Logarithms to a great many Places. This amounts to the resolving this Equation $ly = 0,29$, or $ly - 0,29 = 0$. Hence therefore we have $x = lx - 0,29$, $\dot{x} = \frac{a}{x}$ (a being the *Modulus* belonging to the Table we use, *viz.* 0,434294481 9, &c.) $\ddot{x} = \frac{-a}{z^2}$, $\dddot{x} = \frac{2a}{z^3}$, $\ddddot{x} = \frac{-6a}{z^4}$, &c.

In this Case because $\ddot{x}$ has a negative Sign, changing the Signs of all the Coefficients, the Canon for v will be found in the fourth Case, which in the irrational Form gives $v = \frac{\dot{x}}{\ddot{x}}\sqrt{\frac{\dot{x}^2}{\ddot{x}^2} + \frac{2x}{\ddot{x}} - \frac{2\dddot{x}}{2 \cdot 3\ddot{x}}v^3 - \frac{2\ddddot{x}}{2 \cdot 3 \cdot 4\ddot{x}}v^4}$ &c. $= z - \sqrt{z^2 + \frac{2lz - 0,58}{a} \times z^2 + \frac{2v^3}{3z} - \frac{2v^4}{4z^2} + \frac{2v^5}{5z^3}}$ &c. In this Case to avoid often dividing by z, it will be most convenient to compute $\frac{v}{z}$, which is got from this Equation $\frac{v}{z} = 1 - \sqrt{1 + \frac{2lz - 0,58}{a} + \frac{2v^3}{3z^3} - \frac{2v^4}{4z^4} + \frac{2v^5}{5z^5}}$, &c. The nearest Logarithm,

rithm, in the Tables propoſed, to the propoſed Logarithm 0,29 is 0,2900346114, its Number being 1,95. Therefore for the firſt Suppoſition taking $z = 1,95$, we have $x\ (= lz - 0,29 = 0,2900346114 - 0,29) = 0,0000346114$, and $\frac{2lz - 0,58}{a} = \frac{0,0000692228}{0,4342944819} = 0,00015939139$, and $1 + \frac{2lz - 0,58}{a} = 1,00015939139$. Whence for the firſt Approximation we have $\frac{v}{z} = 1 - \sqrt{1,00015939139} = -0,00007969247$, and $v = -0,00015540032$, and $y = v + v = 1,94984459968$. Which is true to eleven Places, and may eaſily be corrected by the Terms $\frac{2v^3}{3z}$ *&c.* which I leave to the Reader's Curioſity.

Being upon the Subject of Approximations, it may not be amiſs to ſet down here two Approximations I have formerly hit upon. The one is a Series of Terms for expreſſing the Root of any Quadratic Equation; and the other is a particular Method of approximating in the Invention of Logarithms, which has no Occaſion for any of the Tranſcendental Methods, and is expeditious enough for making the Tables without much Trouble.

A general Series *for expreſſing the* Root *of any Quadratic Equation.*

2. Any Quadratic Equation being reduc'd to this Form $xx - mqx + my = 0$, the Root x will be expreſs'd by this Series of Terms.

$$x = \frac{y}{q} + A \times \frac{1}{\frac{mq^2}{y} - 2} + B \times \frac{1}{a^2 - 2} + C \times \frac{1}{b^2 - 2} + D \times \frac{1}{c^2 - 2}$$ *&c.* which muſt be thus interpreted.

1. The Capital Letters A, B, C, *&c.* ſtand for the whole Terms with their Signs, preceding thoſe wherein they are found, as

$$B = A \times \frac{1}{\frac{mq^2}{y} - 2}.$$

2. The

2. The little Letters *a*, *b*, *c*, *&c.* in the Diviſors, are equal to the whole Diviſors of the Fraction in the Terms immediately preceding; thus $b = a^2 - 2$.

For an Example of this, let it be required to find $\sqrt{2}$. Putting $\sqrt{2} = x + 1$, we have $x^2 + 2x - 1 = 0$, which being compared with the general *Formula*, gives $mq = -2$, and $my = -1$: therefore for m taking -1, we have $q = 2$, and $y = 1$, which Values ſubſtituted in the Series give $x = \frac{1}{2} - \frac{1}{2 \times 6} - \frac{1}{2 \times 6 \times 34} - \frac{1}{2 \times 6 \times 34 \times 1154} - \frac{1}{2 \times 6 \times 34 \times 1154 \times 1331714}$, *&c.* The Fractions here wrote down giving the Root true to twenty three Places.

3. This Method is founded upon theſe Conſiderations.

1. That the Sum of the Logarithms of any two Numbers is the Logarithm of the Product of thoſe two Numbers multiplied together.

A New Method of computing Logarithms.

2. That the Logarithm of Unite is nothing; and conſequently that the nearer any Number is to Unite, the nearer will its Logarithm be to 0. 3*dly*, That the Product by Multiplication of two Numbers, whereof one is bigger, and the other leſs than Unite, is nearer to Unite than that of the two Numbers which is on the ſame Side of Unite with itſelf; for Example, the two Numbers being $\frac{3}{3}$ and $\frac{4}{3}$, the Product $\frac{12}{9}$ is leſs than Unite, but nearer to it than $\frac{2}{3}$, which is alſo leſs than Unite. Upon theſe Conſiderations, I found the preſent Approximation; which will be beſt explain'd by an Example. Let it therefore be propoſed to find the Relation of the Logarithms of 2 and of 10.

In order to this, I take two Fractions $\frac{128}{100}$ and $\frac{8}{10}$, *viz.* $\frac{\overline{2}|^7}{\overline{10}|^2}$ and $\frac{\overline{2}|^3}{\overline{10}|^1}$ whoſe Numerators are Powers of 2, and their Denominators Powers of 10; one of them being bigger, and the other leſs than 1. Having ſet theſe down in Decimal Fractions in the firſt Column of the Table annex'd, againſt them in the ſecond Column I ſet *A* and *B* for their Logarithms, expreſſing by an Equation the manner how they are compounded of the Logarithms of 2 and 10, for which I write *l* 2 and *l* 10. Then multiplying the two Numbers in the firſt Column together, I have a third Number 1, 024, againſt which I write *C* for its Logarithm, expreſſing likewiſe by an Equation in what manner *C* is formed of the foregoing Logarithms *A* and *B*. And in the ſame manner the Calculation is continued; only obſerving this *Compendium*, that be-

before I multiply the two laſt Numbers already got in the Table, I conſider what Power of one of them muſt be uſed to bring the Product the neareſt to Unit that can be. This is found, after we have gone a little way in the Table, only by dividing the Differences of the Numbers from Unit one by the other, and taking the Quotient with the neareſt, for the Index of the Power wanted. Thus the two laſt Numbers in the Table being 0,8 and 1,024, their Differences from Unit are 0,200 and 0,024; therefore $\frac{0,200}{0,024}$ gives 9 for the Index; wherefore multiplying the ninth Power of 1,024 by 0,8, I have the next Number 0,990352031429, whoſe Logarithm is $D = 9C + B$. In ſeeking the Index in this Manner by Diviſion of the Differences, the Quotient ought generally to be taken with the leaſt: but in the preſent Caſe it happens to be the moſt, becauſe inſtead of the Difference between 0,8 and 1, we ought ſtrictly to have taken the Difference between the reciprocal 1,25 and 1, which would have given the Index 10; and that would be too big, becauſe the Product by that Means would have been bigger than 1, as 1,024 is. Whereas this Approximation requires that the Numbers in the firſt Column be alternately greater and leſs than 1, as may be ſeen in the Table.

When I have in this Manner continued the Calculation, till I have got the Numbers ſmall enough, I ſuppoſe the laſt Logarithm to be equal to nothing. Which gives me an Equation, from which having got away the Letters by Means of the foregoing Equations, I have the Relation of the Logarithms propoſed. In this Manner if I ſuppoſe $G = 0$, I have $2136\,l\,2 - 643\,l\,10 = 0$. Which gives the Logarithm of 2 true in ſeven Figures, and too big in the Eighth; which happens becauſe the Number correſponding with G is bigger than Unit.

There is another Expedient which renders this Calculation ſtill ſhorter. It is founded upon this Conſideration, that when x is very ſmall $\overline{1+x}|^n$ is very nearly $1+nx$. Hence if $1+x$, and $1-z$ are the two laſt Numbers already got in the firſt Column of the Table, their Powers $\overline{1+x}|^m$ and $\overline{1-z}|^n$ are ſuch as will make the Product $\overline{1+x}|^m \times \overline{1+z}|^n$ very near to Unit, m and n may be found thus: $\overline{1+x}|^m = \overline{1+mx}$, and $\overline{1-z}|^n = 1-nz$, and conſequently $\overline{1+x}|^m \times \overline{1-z}|^n = 1+mx-nz-mnzx$, or (neglecting $mnzx$) $1+$

mx

1,280000000000	$A = 7\ l2 - 2\,l10$		$l2 > 0{,}28$
0,800000000000	$B = 3\ l2 - l10$		$> 0{,}33$
1,024000000000	$C = B + A = 10\,l2 - 3\,l10$		$> 0{,}300$
0,990352031429	$D = 9\ C + B = 93\,l2 - 28\,l10$		$< 0{,}30107$
1,004336277664	$E = 2\ D + C = 169\,l2 - 59\,l10$		$> 0{,}301020$
0,998959536107	$F = 2\ E + D = 485\,l2 - 146\,l10$		$< 0{,}3010309$
1,000162894165	$G = 4\ F + E = 2136\,l2 - 643\,l10$		$> 0{,}30102996$
0,999936281874	$H = 6\ G + F = 13301\,l2 - 4004\,l10$		$< 0{,}301029997$
1,000035441215	$I = 2\ H + G = 28738\,l2 - 8651\,l10$		$> 0{,}30102999951$
0,999971720830	$K = \ I + H = 42039\,l2 - 12655\,l10$		$< 0{,}30102999959$
1,000007161046	$L = \ K + I = 70777\,l2 - 21306\,l10$		$> 0{,}30102999562$
0,999993203514	$M = 3\ L + K = 254370\,l2 - 76573\,l10$		$< 0{,}30102999567$
1,000000364511	$N = \ M + L = 325147\,l2 - 97879\,l10$		$> 0{,}30102999566635$
0,999999764687	$O = 18\,N + M = 6107016\,l2 - 1838395\,l10$		$< 0{,}30102999566640$
Com. Ar. 235313			
$0 = 364511\,O + 235313$	$N = 2302585825187\,l2 - 693147400972\,l10$		$> 0{,}30102999566398\overline{7}$

$mx = nz$. Make this equal to 1, and we have

$m : n :: z : x :: l\ 1 - z : l\ \frac{1}{1+x}$. Whence $x\,l\,1 - z = z\,l\,1 + x$. To give an Example of the Application of this, let 1,024 and 0,990352 be the laſt Numbers in the Table, their Logarithms being C and D. Then we have $1{,}024 = 1 + x$, and $0{,}990352 = 1 - z$, and conſequently $x = 0{,}024$, and $z = 0{,}009648$. Whence the Ratio $\frac{z}{x}$ in the leaſt Numbers is $\frac{201}{500}$. So that for finding the Logarithms propoſed we may have $500\,D + 201\,C = 485102 - 14603\,l\,10 = 0$; which gives $l2 = 0{,}3010307$, which is too big in the laſt Figure; but it is nearer the Truth than what is got from the Logarithm F ſuppoſed equal to nothing. So that by this Means we have ſaved four Multiplications, which were neceſſary to find the Number 9989595 &c. correſpondent to F, and which muſt have been had if we would make the Logarithm true to the ſame Number of Places without this *Compendium*.

I have compured this Table ſo far, that the Reader may ſee in what Manner this Method approximates; this whole Work as it appears requiring a little more than three Hours Time.

Of Infinite Series's, the 1ſt Part, *by* P. R. *de* Monmort. n. 353. p. 633.

XVIII. 1. *Prop.* 1. *Prob.* Invenire ſummam terminorum quot libuerit Seriei hujus $a \times \overline{a+n} \times \overline{a+2n} \times \&c. \times \overline{a+p-1\,n}$

$+ \overline{a+n} \times \overline{a+2n} \times \overline{a+3n} \times \&c. \times \overline{a+pn}$

$+ \overline{a+2n} \times \overline{a+3n} \times \overline{a+4n} \times \&c. \times \overline{a+p+1\,n}$

$+ a+3n \times \&c.$ Ubi eſt n differentia data, tam inter Factores continuos, a, $a+n$, $a+2n$, *&c.* ejuſdem cujuſvis termini, quàm inter Factores homologos terminorum diverſorum in Serie continuatâ; atque deſignat p numerum factorum hujuſmodi in quovis termino.

Solutio. Per x deſignetur primus Factorum in ultimo terminorum quorum ſumma requiritur, atque ſumma illa erit

$$\frac{x \times \overline{x+n} \times \&c. \times \overline{x+pn} - \overline{a-n} \times a \times \&c. \times \overline{a+p-1\,n}}{\overline{p+1\,n}}$$

Q. E. I.

Ex. 1. Proponatur Series numerorum naturalium $1+2+3+4+\&c.$ & invenienda ſit ſumma tot terminorum quot ſunt unitates in numero z, qui in hoc caſu eſt etiam ultimus terminorum quorum ſumma requiritur. In hoc itaque caſu ſunt $a=1$, $n=1$, $p=1$, & $x=z$. Unde fit $x \times \overline{x+n} \times \&c. \times \overline{x+pn} = z \times \overline{z+1}$, $\overline{a-n} \times a \times \&c. \times \overline{a+p-1\,n} = 0 \times 1$, atque $\overline{p+1\,n} = 2 \times 1$; adeoque ſumma quæſita eſt $\frac{z \times z+1}{2}$.

Ex. 2. Invenienda ſit ſumma tot terminorum, quot ſunt unitates in numero z, Seriei $1+3+6+10+\&c.$ Numerorum Triangularium. Numeri 1, 3, 6, 10, *&c.* in hac Serie ſic ſcribi poſſunt $\frac{1 \times 2}{2}$, $\frac{2 \times 3}{2}$, $\frac{3 \times 4}{2}$, $\frac{4 \times 5}{2}$, *&c.* Hoc pacto, ſepoſito diviſore dato 2, Series revocatur ad formam Propoſitionis, exiſtentibus $a=1$, $n=1$, & $p=2$, $x=z$. Unde ſumma Seriei duplicata eſt

$$\frac{x\times\overline{x+1}\times\overline{x+2}-0\times1\times2}{3}=\frac{x\times\overline{x+1}\times\overline{x+2}}{3}$$

adeoque habitâ ratione diviſoris 2, Summa Seriei ipſius eſt

$\frac{x\times\overline{x+1}\times\overline{x+2}}{2\times3}$, vel $\frac{z\times\overline{z+1}\times\overline{z+2}}{2\times3}$, in hoc caſu exiſtente x eo-

dem ac z. Ad eundem modum inveniuntur ſummæ cæterorum numerorum figuratorum, quorum formulæ jam vulgò innoteſcunt.

Ex. 3. Sint $a=1$, $n=2$, $p=3$, ut ſit Series propoſita $1\times3\times5+3\times5\times7+5\times7\times9+$ &c. In hoc itaque caſu formula ſummæ fit

$$\frac{x\times\overline{x+2}\times\overline{x+4}\times\overline{x+6}-\overline{1-2}\times1\times3\times5}{4\times2}=$$

$\frac{x\times\overline{x+2}\times\overline{x+4}\times\overline{x+6}+15}{8}$. Verbi gratiâ, ſi quæratur ſumma

decem terminorum, fit $x=19$ (nempe terminus decimus in Serie arithmeticè proportionalium, 1, 3, 5, 7, &c.) adeoque ſumma eſt

$\frac{19\times21\times23\times25+15}{8}=28680$. Propoſitio vero ſic demonſtratur.

Demonſtratio. Sit Series quantitatum A, B, C, D, E, &c. quarum differentiæ conſtituant Seriem a, b, c, d, &c. (nempe ut ſint $a=B-A$, $b=C-B$, $c=D-C$, &c.) Hinc ſtatim colligitur eſſe $a+b=C-A$, $a+b+c=D-A$, $a+b+c+d=E-A$: & in genere aggregatum quotlibet terminorum Seriei a, b, c, d, &c. æquale eſt termino proximè inſequenti Seriei A, B, C, D, E, &c. mulctato termino primo A. Pro A, B, C, &c. ſume terminos

$$\frac{\overline{a-n}\times a\times\&c.\times\overline{a+\overline{p-1}\,n}}{\overline{p+1}\,n},\quad\frac{a\times\overline{a+n}\times\&c.\times\overline{a+pn}}{\overline{p+1}\,n}$$

$\frac{\overline{a+n}\times\overline{a+2n}\times\&c.\times\overline{a+\overline{p+1}\,n}}{\overline{p+1}\,n}$, &c. hoc eſt, valores ſucceſſi-

vos ipſius $\frac{x \times \overline{x \dotplus n} \times \&c. \times \overline{x \dotplus pn}}{\overline{p \dotplus 1 n}}$; & eorum differentiæ, pro *a*, *b*, *c*, *d*, *&c.* ſumendæ, erunt $a \times \overline{a \dotplus n} \times \&c. \times \overline{a \dotplus p - 1 n}$, $\overline{a \dotplus n} \times \overline{a \dotplus 2n} \times \&c. \times \overline{a \dotplus pn}$, *&c.* qui ſunt ipſiſſimi termini Seriei propoſitæ. Sed comparando has Series, ſi terminus aliquis Seriei poſterioris ſit $x \times \overline{x \dotplus n} \times \&c. \times \overline{\overline{x \dotplus p - 1 n}}$, conſtat terminum uno ulteriorem in Serie priori fore $\frac{x \times \overline{x \dotplus n} \times \&c. \times \overline{x \dotplus pn}}{\overline{p \dotplus 1 n}}$. Summa itaque Seriei poſterioris uſque terminum $x \times \overline{x \dotplus n} \times \&c. \times \overline{\overline{x \dotplus p - 1 n}}$ incluſivè eſt $\frac{x \times \overline{x \dotplus n} \times \&c. \times \overline{x \dotplus pn} - \overline{a - n} \times a \times \&c. \times \overline{\overline{a \dotplus p - 1 n}}}{\overline{p \dotplus 1 n}}$. *Q. E. D.*

Scholium 1. In hâc propoſitione continetur particula quædam Methodi incrementorum, de quâ ante biennium librum edidit D. *Brook Taylor Soc. Reg. Lond. Secr.* mihi amicitiâ conjunctiſſimus. Librum ipſum adeat qui de eâ methodo plura ſcire velit: ad inſtitutum noſtrum ſufficit obſervare quanta interſit affinitas inter Methodum hanc & Methodum Fluxionum ſeu differentialem. Nam ut in Methodo differentiali, ad inveniendum differentiale ipſius *x* dignitatis x^m, unum latus *x* convertendum eſt in differentiam dx; & ortum ducendum eſt in dignitatis Indicem *m*, ut fit $m\,dx\,x^{m-1}$ differentiale quæſitum; ſic in Methodo incrementorum *Ad inveniendum Incrementum facti hujuſmodi* $x \times \overline{x \dotplus n} \times \overline{\overline{x \dotplus 2n}}$, (*ubi factores* x, $x \dotplus n$, $x \dotplus 2n$, *ſunt in progreſſione Arithmeticâ, cujus differentia communis eſt ipſius x Incrementum datum n,*) *Factorum minimus x convertendus eſt in Incrementum, & ortum ducendum eſt in numerum Factorum, ut ſit* $3n \times \overline{x \dotplus n} \times \overline{x \dotplus 2n}$ *Incrementum quæſitum, numero Factorum in caſu expoſito exiſtente* 3. Sic etiam ipſius $x \times \overline{x \dotplus n}$ Incrementum fit $2n \times \overline{x \dotplus n}$.

2. In-

2. Incrementa etiam Reciprocorum hujuſmodi Factorum inveniuntur per eandem regulam; hoc nempe obſervato, quòd cum ſit Diviſio contrarium Multiplicationis, vice ablationis minimi Factorum, ſit jam addendus alius factor adhuc uno Incremento major; item quòd Factorum numerus ſit ſcribendus cum ſigno negativo. Hoc pacto ipſius $\frac{1}{x}$ Incrementum fit $\frac{-1 \times n}{x \times x \overline{+ n}}$; ipſius $\frac{1}{x \times x \overline{+ n}}$ incrementum fit $\frac{-2 \times n}{x \times x \overline{+ n} \times x \overline{+ 2n}}$; & ſic de aliis hujuſmodi. Hoc facile probatur ſumendo differentias inter Integralium valores duos continuos.

3. Inſiſtendo veſtigiis Methodi directæ, hinc colliguntur præcepta Methodi inverſæ, quibus inveniuntur Integralia Incrementorum oblatorum. *Applicetur* enim *Incrementum oblatum ad lateris Incrementum datum*; *addatur Factor adhuc uno Incremento minor*, *& applicetur ortum ad numerum Factorum ſic auctorum.* Sic *e. g.* oblato Incremento $n \times x \times \overline{x \overline{+ n} \times x \overline{+ 2n}}$, fit primò $x \times \overline{x \overline{+ n} \times x \overline{+ 2n}}$; deinde $\overline{x - n} \times x \times \overline{x \overline{+ n} \times x \overline{+ 2n}}$, addito Factore $\overline{x - n}$; denique $\frac{\overline{x - n} \times x \times \overline{x \overline{+ n} \times x \overline{+ 2n}}}{4}$, quod eſt Integrale quæſitum. Hoc quidem ubi Factores ſunt Multiplicantes; ubi vero Factores occupant locum diviſoris, mutatis mutandis regula hæc eſt, *Applicetur Incrementum oblatum ad lateris incrementum datum*; *rejiciatur Factorum maximus*, *& applicetur ortum ad numerum Factorum relictorum cum ſigno negativo.* Exempli gratiâ oblato Incremento $\frac{n}{x \times x \overline{+ n} \times x \overline{+ 2n}}$, fit primò $\frac{1}{x \times x \overline{+ n} \times x \overline{+ 2n}}$, deinde $\frac{1}{x \times x \overline{+ n}}$ denique $\frac{1}{-2 \times x \times x \overline{+ n}}$, ſeu $\frac{1}{2 x \times x \overline{+ n}}$, quod eſt Integrale quæſitum.

4. In caſu hoc noviſſimo Integrale inventum, cum ſigno contrario, æquale eſt ſummæ omnium Incrementorum in Serie in infinitum continuatâ; *v. g.*

$$v.g.\ \text{eſt}\ \frac{1}{2x\times\overline{x+n}} = \frac{n}{x\times\overline{x+n}\times\overline{x+2n}}$$

$$+\frac{n}{\overline{x+n}\times\overline{x+2n}\times\overline{x+3n}}+\frac{n}{\overline{x+2n}\times\overline{x+3n}\times\overline{x+4n}}+\&c.$$

Nam in hoc caſu, facto x tandem infinito, evaneſcit $\frac{1}{2x\times\overline{x+n}}$, hoc eſt, ultimus terminorum A, B, C, $\&c.$ fit nihil; & ob contrarietatem ſignorum Integralis & Incrementi, vice $-A$ exprimitur aggregatum per $+A$.

Lemma 1.] Per X deſignetur terminus quilibet in Serie quâvis numerorum M, N, O, P, $\&c.$ per x deſignetur locus termini iſtius X in Serie illâ (*v.g.* ut ſit $x=1$, quando deſignat X terminum primum M, ſit $x=2$, quando deſignat X terminum ſecundum N, & ſic de cæteris) & ſint terminorum M, N, O, P prima differentiarum primarum b, c prima differentiarum ſecundarum, d prima tertiarum, e prima quartarum, & ſic porrò. Tum erit

$$X=M+b\times\frac{x-1}{1}+c\times\frac{x-1}{1}\times\frac{x-2}{2}+d\times\frac{x-1}{1}$$

$$\times\frac{x-2}{2}\times\frac{x-3}{3}+e\times\frac{x-1}{1}\times\frac{x-2}{2}\times\frac{x-3}{3}\times\frac{x-4}{4}+$$

$\&c.$ Sequitur hoc ex tabulâ æquationum *pag.* 66. tractatûs noſtri *Eſſay d'Analyſe*, $\&c.$

Lemma 2.] Iiſdem poſitis, per z deſignetur terminus quilibet in Serie Arithmeticè proportionalium a, $a+n$, $a+2n$, $\&c.$ & ſit jam

$$X=A+Bz+Cz\times\overline{z+n}+Dz\times\overline{z+n}\times\overline{z+2n}+Ez\times\overline{z+n}$$

$$\times\overline{z+2n}\times\overline{z+3n}+\&c.$$

Tum ipſorum A, B, C, D, E, $\&c.$ valores erunt.

$A=$

$$A = M + b \times \frac{-a}{n} + c \times \frac{-a}{n} \times \frac{-a-n}{2n}$$

$$+ d \times \frac{-a}{n} \times \frac{-a-n}{2n} \times \frac{-a-2n}{3n}$$

$$+ e \times \frac{-a}{n} \times \frac{-a-n}{2n} \times \frac{-a-2n}{3n} \times \frac{-a-3n}{4n} + \&c.$$

$$B = \frac{1}{n} \times b + c \times \frac{-a-n}{n} + d \times \frac{-a-n}{n} \times \frac{-a-2n}{2n}$$

$$+ e \times \frac{-a-n}{n} \times \frac{-a-2n}{2n} \times \frac{-a-3n}{3n} \&c.$$

$$C = \frac{1}{n} \times \frac{1}{2n} \times c + d \times \frac{-a-2n}{n} + e \times \frac{-a-2n}{n} \times \frac{-a-3n}{2n} + \&c.$$

$$D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} d + e \times \frac{-a-3n}{n} + \&c.$$

$$E = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times \frac{1}{4n} e + \&c.$$

Ordo formandi coefficientes ipſorum b, c, d, e, $\&c.$ in his valoribus, per ſe eſt ſatis manifeſtus.

Demonſtratio. Quoniam per x & z deſignantur termini correſpondentes progreſſionum Arithmeticarum, 1, 2, 3, 4, $\&c.$ & a, $a + n$, $a + 2n$, $a + 3n$, $\&c.$ indicabit $x - 1$ numerum differentiarum n qui in z continetur, ut ſit $z = a + \overline{x-1}\, n$. Hinc fit $x - 1 = \frac{z-a}{n}$, $x - 2 = \frac{z-n-a}{n}$, $x - 3 = \frac{z-2n-a}{n}$, $\&c.$ Subſtituendo itaque hos valores $x - 1$, $x - 2$, $x - 3$, $\&c.$ in Serie Lemmatis præcedentis, & terminis in ordinem redactis, prodeunt ipſorum A, B, C, $\&c.$ valores exhibiti.

Cor.

Cor. Ubi $a = n$, prodeunt $A, B, C, D, \&c.$ per formulas ſimpliciores, nempe

$$A = M - b + c - d + e \;\&c.$$

$$B = \frac{1}{n} \times \overline{b - 2c + 3d - 4e \;\&c.}$$

$$C = \frac{1}{n} \times \frac{1}{2n} \times \overline{c - 3d + 6e \;\&c.}$$

$$D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times \overline{d + 4e \;\&c.}$$

Lemma 3.] Symbolis X & x eodem modo interpretatis ac in Lemmate primo, ſint $q, r, s, t, u, \&c.$ generatores Trianguli Arithmetici cujus lineam tranſverſam, occupat Series $M, N, O, P, Q, \&c.$ in ordine nempe inverſo, ut ſit $q\ (= M)$ generator ultimus, r penultimus, s antepenultimus, & ſic porrò. Tum erit

$$X = q + r \times \frac{x-1}{1} + s \times \frac{x-1}{1} \times \frac{x}{2} + t \times \frac{x-1}{1} \times \frac{x}{2} \times \frac{x+1}{3} + \&c.$$

Conſtat ex contemplatione ipſius Trianguli Arithmetici, quam exhibuimus *pag.* 63. tractatûs *Eſſay d'Analyſe, &c.* ubi idem fuſius explicatur.

Lemma 4.] Iiſdem poſitis, & Symbolo z eodem modo interpretato ac in *Lem.* 2. ſi ſit $X = A + Bz + Cz \times \overline{z + n} + \&c.$ ut in *Lem.* 2. erunt coefficientium $A, B, C, D, \&c.$ valores.

$$A = q + r \times \frac{-a}{n} + s \times \frac{-a}{n} \times \frac{-a+n}{2n}$$

$$+ t \times \frac{-a}{n} \times \frac{-a+n}{2n} \times \frac{-a+2n}{3n} + \&c.$$

$$B = \frac{1}{n} \times r + s \times \frac{-a}{n} + t \times \frac{-a}{n} \times \frac{-a+n}{2n} + \&c.$$

$C =$

$$C = \frac{1}{n} \times \frac{1}{2n} \times s + t \times \frac{-a}{n} + \&c.$$

$$D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times t + \&c.$$

Ordo coefficientium in his valoribus eſt manifeſtus, & demonſtratur Lemma ad modum *Lemmatis* 2.

Cor. 1. Ubi $a = n$, coefficientes, A, B, C, D, &c. prodeunt per formulas ſimpliciores, nempe

$$A = q - r, \qquad C = \frac{1}{n} \times \frac{1}{2n} \times \overline{s - t}$$

&c.

$$B = \frac{1}{n} \times \overline{r - s}, \quad D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \overline{t - u}$$

Cor. 2. Unde ſi generatorum q, r, s, t, u, &c. aliquot ſint inter ſe æquales, exhibebitur X per formulam ſimpliciorem, evaneſcentibus aliquot coefficientium A, B, C, D, &c.

Sic exempli gratiâ, propoſitâ Serie numerorum 4, 69, 530, 2676, 10350, &c. qui conſtituunt lineam decimam tranſverſam in Triangulo Arithmetico cujus generatores tres priores ſunt 54, — 18, 5, & ſeptem poſteriores ſunt æquales 4; exiſtente $a = 1 = n$, Terminus X exhibetur per formulam quatuor tantùm terminorum.

$$\frac{z}{1}. \frac{z+1}{2}. \frac{z+2}{3} \&c. \times \frac{z+6}{7} + 23 \frac{z}{1}. \frac{z+1}{2}. \&c.$$

$$\times \frac{z+6}{7} - 72 \frac{z}{1}. \frac{z+1}{2}. \&c. \times \frac{z+7}{8} + 54 \frac{z}{1}. \frac{z+1}{2}, \&c.$$

$$\times \frac{z+8}{9}.$$ evaneſcentibus coefficientibus ſex primis A, B, C, D, E, F.

Prop. II. *Prob.*] Invenire ſummam quotlibet terminorum Seriei

$$\frac{M}{a\times\overline{a+n}\times\&c.\times\overline{a+p-1\,n}}+\frac{N}{\overline{a+n}\times\&c.\times\overline{a+p\,n}}$$

$$+\frac{O}{\overline{a+2\,n}\times\&c.\times\overline{a+p+1\,n}}+\&c.$$ ubi numeratores M, N, O, &c. conſtituunt Seriem quamlibet terminorum, quorum differentiæ, vel primæ, vel ſecundæ, vel aliæ quædam dantur; vel quod perinde eſt, qui conſtituunt lineam quamvis tranſverſam in dato quovis triangulo Arithmetico; Denominatores autem conſtituunt Seriem in *Prop.* I. exhibitam.

Solutio. Per X deſignetur primus factorum a, $a+n$, $a+2\,n$, &c. in Denominatore ejuſdem termini, ut ſint X & z iidem ac in *Lemm.* præmiſſis, adeoque deſignetur terminus quilibet Seriei per

$$\frac{X}{z\times\overline{z+n}\times\&c.\times\overline{z+p-n}}$$ Per *Lem.* 2, vel per *Lem.* 4. (prout magis commodum videatur vel differentias, vel generatores trianguli Arithmetici adhibere,) reſolvatur X in Multinomium $A+B\times z+Cz\times\overline{z+n}+Dz\times\overline{z+n}\times\overline{z+2n}+\&c.$ Hoc pacto (terminis multinomii ad Denominatorem $z\times\overline{z+n}\times\&c.+z+\overline{p-n}$, applicatis) terminus quilibet Seriei revocabitur ad formulam $\frac{A}{z\times\overline{z+n}\times\&c.\times\overline{z+p-1\,n}}$

$$+\frac{B}{\overline{z+n}\times\&c.\times\overline{z+p-1\,n}}+\frac{C}{\overline{z+2\,n}\times\&c.\times\overline{z+p-1\,n}}$$

$+\&c.$

Unde (per Scholium 4. *Prop.* I.) aggregatum totius Seriei, à termino $\frac{X}{z\times z+n\times\&c.\times\overline{z+p-1\,n}}$ incluſivè in infinitum continuatæ, eſt

$$\frac{A}{\overline{p-1}\times n\times z\times\overline{z+n}\times \&c.\times\overline{z+p-2n}}$$

$$+\frac{B}{\overline{p-2}\times n\times\overline{z+n}\times \&c.\times\overline{z+p-2n}}$$

$$+\frac{C}{\overline{p-3}\times n\times\overline{z+2n}\times \&c.\times\overline{z+p-2n}}$$

ſi dematur hoc aggregatum ab ejuſdem aggregati valore quando $z=a$, reſiduum erit ſumma omnium terminorum ante terminum $\frac{X}{z+\&c.}$, hoc eſt, tot terminorum quot ſunt unitates in $\frac{z-a}{n}$.

Q. E. I.

Ex. 1. Sit primum exemplum in Serie $\frac{5}{3\cdot5\cdot7\cdot9\cdot11\cdot13}$

$$+\frac{41}{5\cdot7\cdot9\cdot11\cdot13\cdot15}+\frac{131}{7\cdot9\cdot11\cdot13\cdot15\cdot17}$$

$$+\frac{275}{9\cdot11\cdot13\cdot15\cdot17\cdot19}+\frac{473}{11\cdot13\cdot15\cdot17\cdot19\cdot21}$$

$+\&c.$ Sunt hic $a=3$, $n=2$, $p=6$, $M=5$, & capiendo differentias numeratorum inveniuntur $b=36$, $c=54$, $d=0=e=\&c.$ Hinc in Lemmate ſecundo ſunt $A=5+36\times\frac{-3}{2}+54\times\frac{-3}{2}\times\frac{-5}{4}=\frac{209}{4}$,

$B=\frac{1}{2}\times36+54\times\frac{-5}{2}=\frac{-99}{2}$, $C=\frac{1}{2}\times\frac{1}{4}\times54=\frac{27}{4}$,

$D=0=E=\&c.$ Summa itaque totius Seriei eſt

$$\frac{209}{4\times5\times2\times3\cdot5\cdot7\cdot9\cdot11}+\frac{-99}{2\times4\times2\times5\cdot7\cdot9\cdot11}$$

$$+\frac{27}{4\times3\times2\times7\cdot9\cdot11}=\frac{283}{80\times3..5\cdot7\cdot9\cdot11},$$ atque ſumma terminorum numero $\frac{z-3}{2}$ $(=\frac{z-a}{n})$ eſt $\frac{283}{80\times3\cdot5\cdot7\cdot9\cdot11}$

$$-\frac{209}{40\times z.\overline{z+2}.\overline{z+4}.\overline{z+6}.\overline{z+8}}+\frac{99}{16\times z+2\times z+4.\overline{z+6}.\overline{z+8}}$$

$$-\frac{27}{24\times z+4.\overline{z+6}.\overline{z+8}}$$ Quærantur *v. g.* octo termini; tum exiſtente $\frac{z-3}{2}=8$ fit $z=19$, quo valore in formulâ adhibito, prodit ſumma

$$\frac{155891}{2\cdot3\cdot3\cdot3\cdot3\cdot5\cdot5\cdot5\cdot7\cdot11\cdot19\cdot23}.$$

Iidem Numeratores occupant lineam tertiam tranſverſam in Triangulo Arithmetico

$$\begin{array}{rrrrrrr} 54 & \cdot\ 54 & \cdot\ 54 & \cdot\ 54 & \cdot\ 54 & \cdot\ 54 & \cdot\ \&c. \\ - & 18 & \cdot\ 36 & \cdot\ 90 & \cdot\ 144 & \cdot\ 198 & \cdot\ \&c. \\ & & 5 & \cdot\ 41 & \cdot\ 131 & \cdot\ 275 & \cdot\ \&c. \end{array}$$

Unde in formula *Lem.* 4. ſunt Generatores $q=5, r=-18$; $s=54$, $t=0=\&c.$ & prodeunt coefficientes $A=5-18\times\frac{-3}{2}+$

$$\times54\,\frac{-3}{2}\times\frac{-3+2}{4}=\frac{209}{4},\ B=\frac{1}{2}\times-\overline{18+54\times\frac{-3}{2}}=\frac{-99}{2},$$

$C=\frac{1}{2}\times\frac{1}{4}\times54=\frac{27}{4}$, $D=0=E=\&c.$ iidem ac ſupra.

Ex. 2.

Ex. 2. Sit Series $\frac{4}{1.2.3.4.5.6.7.8.9.10.11}$

$$+\frac{69}{2.3.\&c.12}+\frac{530}{3.4.\&c.13}+\frac{2676}{4.5.\&c.14}+\frac{10350}{5.6.\&c.15}$$

$+\&c.$ Ubi ſunt $a=1$, $n=1$, $p=11$, atque Numeratores conſtituant Seriem in *Corol.* 20. *Lem.* 4. exhibitam. Applicando itaque valorem X in *Corol.* illo ad denominatorem $z\times\overline{z+1}\times\&c.\times\overline{z+10}$, fit Seriei propoſitæ Terminus

$$\frac{-1}{1.2.3.4.5.6\times\overline{z+6}.\overline{z+7}.\overline{z+8}.\overline{z+9}.\overline{z+10}}$$

$$+\frac{23}{1.2.3.4.5.6.7\times\overline{z+7}.\overline{z+8}.\overline{z+9}.\overline{z+10}}$$

$$-\frac{72}{1.2.3.4.5.6.7.8\times\overline{z+8}.\overline{z+9}.\overline{z+10}}$$

$$+\frac{54}{1.2.3.4.5.6.7.8.9\times\overline{z+9}\times\overline{z+10}}.$$ Adeoque per hanc

Prop. Summa Seriei à termino illo in infinitum continuatæ eſt

$$\frac{-1}{4\times1.2.3.4.5.6\times\overline{z+6}.\overline{z+7}.\overline{z+8}.\overline{z+9}}$$

$$+\frac{23}{3\times1.2.3.4.5.6.7\times\overline{z+7}.\overline{z+8}.\overline{z+9}}$$

$$-\frac{72}{2\times1.2.3.4.5.6.7.8\times\overline{z+8}.\overline{z+9}}$$

$+$

$$+\frac{54}{1\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\times z+9}$$

Itaque pro z ſumpto 1, fit ſumma totius Seriei

$\frac{305}{12\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\cdot10}$. Et in genere ſumma terminorum numero $\frac{z-1}{1}$, eſt $\frac{305}{12\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\cdot10}$

$$+\frac{1}{4\times1\cdot2\cdot3\cdot4\cdot5\cdot6\times\overline{z+6}\cdot\overline{z+7}\cdot\overline{z+8}\cdot\overline{z+9}}$$

$$-\frac{23}{3\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\times\overline{z+7}\cdot\overline{z+8}\cdot\overline{z+9}}$$

$$+\frac{72}{2\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\times\overline{\overline{z+8}\times\overline{z+9}}}$$

$$-\frac{54}{1\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\times\overline{\overline{z+9}}}$$

Scholium 1. In computandis ſummis hujuſmodi Serierum, calculus plerumque levior eſt adhibitis generatoribus trianguli Arithmetici, quam ſi adhibeantur differentiæ. Libet itaque hac occaſione oſtendere quomodo ex datis differentiis inveniri poſſunt generatores Trianguli Arithmetici.

Sunto itaque ω primus Seriei terminus, a differentia ultima data, b prima differentiarum penultimarum, c prima antepenultimarum, & ſic porrò d, e, &c. atque ſint t, u, x, y, &c. generatores quæſiti Trianguli Arithmetici, cujus lineam tranſverſam ordine p occupet Series propoſita. Tum (quod ex contemplatione Trianguli Arithmetici facile conſtat) ſunt

$a =$

$$a = t$$

$$b = \frac{p-1}{1}t + u$$

$$c = \frac{p-1}{1}\times\frac{p-2}{2}t + \frac{p-2}{1}u + x$$

$$d = \frac{p-1}{1}\times\frac{p-2}{2}\times\frac{p-3}{3}t + \frac{p-2}{1}\times\frac{p-3}{2}u$$

$$+\frac{p-3}{1}x + y, \&c$$

Unde colliguntur Generatorum valores

$$t = a$$

$$u = b - \frac{p-1}{1}t$$

$$x = c - \frac{p-1}{1}\times\frac{p-2}{2}t - \frac{p-2}{1}u$$

$$y = d - \frac{p-1}{1}\times\frac{p-2}{2}\times\frac{p-3}{3}t - \frac{p-2}{1}\times\frac{p-3}{2}u$$

$$-\frac{p-3}{1}x \&c.$$

Ultimus autem generator æqualis eſt Seriei termino primo ω.

2. D^nus^ de *Monſoury Abbas Orbacenſis* poſtquam cum eo hæc communicaveram, aliam invenit hujus Problematis Solutionem, cujus formulam ob ejus miram ſimplicitatem hic referre juvat. Itaque in Serie numeratorum ſint ω terminus primus, b prima differentiarum primarum, c prima ſecundarum, d prima tertiarum, & ſic porro; atque ſit termini primi Denominator $z \times \overline{z+n}$ &c. $\times \overline{\overline{z+p-1}\,n}$; Tum ſumma totius Seriei in infinitum continuatæ exhibebitur per formulam

$$\frac{\omega}{n \times \overline{p-1} \times z \times \overline{z+n} \times \&c. \times \overline{z+p-2}\,n}$$

+

$$+\frac{b}{n^2\times\overline{p-1}\times\overline{p-2}\times\overline{z+n}\times\&c.\times\overline{z+p-2n}}+$$

$$\frac{c}{n^3\times\overline{p-1}\times\overline{p-2}\times\overline{p-3}\times\overline{z+2n}\times\&c.\times\overline{z+p-2n}+\&c.}$$

Sit exemplum in Serie $\frac{5}{3\cdot5\cdot\&c.\,13}+\frac{41}{5\cdot7\cdot\&c.\,15}$

$+\frac{131}{7\cdot9\cdot\&c.\,17}+\frac{275}{9\cdot11\cdot\&c.\,19}+\&c.$ cujus ſummam jam exhibuimus. In hoc caſu ſunt $\omega=5$, $b=36$, $c=54$, $d=0=e=\&c.$

Unde per formulam ſumma Seriei integræ fit $\frac{5}{2\cdot5\times3\cdot5\ldots11}$

$+\frac{36}{4\cdot54\cdot\times5\ldots11}+\frac{54}{8\cdot5\cdot4\cdot3\cdot3\times7\ldots11}$

$=\frac{283}{80\times3\cdot5\ldots11}$, ut per formulam noſtram exhibetur. Si quæratur ſumma ejuſdem Seriei incipientis à termino decimo $\frac{2273}{21\ldots31}$,

in eo caſu $\omega=2273$, $b=522$, $c=54$, & ſumma eſſet $\frac{2273}{2\cdot5\times21\ldots29}$

$+\frac{522}{4\cdot5\cdot4\times23\ldots29}+\frac{54}{8\cdot5\cdot4\cdot3\times25\ldots29}$.

Hæc formulæ eſt commodiſſima, & ſummam exhibet nullo ferè negotio, quoties quæritur ſumma Seriei integræ, differentiæ non ſunt nimis multæ. Sed ubi plures ſunt differentiæ, & quæritur non Series integra, ſed termini tantùm initiales aliquam multi, formulæ noſtræ ſunt commodiores.

3. Quan-

3. Quando Serierum termini formantur tantùm per Multiplicationem, nec afficiuntur diviſoribus variabilibus, ſummæ ſemper exhiberi poſſunt per Methodum in *Prop.* I. traditam, ſint licet formulæ quantum libet compoſitæ. Nam poſſunt ſemper revocari ad terminos in formâ quam poſtulat Propoſitio illa. Sic ſi differentiæ ipſorum z & x ſint m & n, & deſignetur terminus Seriei per zx; hic terminus revocabitur ad formam $\overline{a-n}z+\frac{n}{m}z\times\overline{z+m}$; cujus Integrale datur per *Prop.* I.; nempe quoniam $dx=n$, & $dz=m$, eſt $dx=dz\times\frac{n}{m}$; unde regrediendo ad integralia fit $x=\frac{n}{m}z+a$ (adjecto invariabili a, ut habeatur ratio relationis inter z & x in Seriei termino primo,) quod ſic ſcribi poteſt $\overline{a-n}+\frac{n}{m}\times\overline{z+m}$, ut deinde in z ductum induat formam requiſitam. Et ad eundem modum procedere licet in aliis caſibus ejuſmodi. Sed ubi formulæ oblatæ diviſoribus afficiuntur, eædem ac in Calculo integrali, ut vocant, difficultates occurrunt, eâdem induſtriâ ſuperandæ. Nec tamen ſemper ſuperari poſſunt. Nam præterquam quod vix certò ſciri poſſit quæ debeat relatio intercedere inter Numeratorem fractionis & Denominatorem, ut formula oblata ad Integrale revocari poſſit; ſæpe etiam difficillimum eſt explorare an adſit jam talis relatio in formulâ iſtâ, aut ſi deſit, an introduci poſſit. Quicquid ego in hâc materiâ potiſſimum inveni, continetur in tribus ſequentibus propoſitionibus.

Prop. III. *Prob.*] Creſcentibus, z, u, y, x, *&c.* per differentias datas n, m, l, o, *&c.* invenire valorem numeratoris integri N, ut exiſtente Denominatore $z\,.\,\overline{z+n}\,.$ *&c.* $\overline{z+pn}\times u\,.\,\overline{u+m}\,.$ *&c.* $\overline{u+qm}\times y\,.\,\overline{y+l}\,.$ *&c.* $\overline{y+rl}\times x\,.\,\overline{x+o}$ *&c.* $\overline{x+so}\,.$ *&c.* Fractio ad Integrale revocari poſſit.

Solutio. Fiat $N=\overline{\overline{z+pn}\times\overline{u+qm}}\times\overline{y+rl}\times\overline{x+so}\times$ *&c.* $-zu\,yx$ *&c.* atque Integrale erit fractio, cujus Denominator $z\,.\,\overline{z+n}\,.$ *&c.*

$\&c.\ \overline{z+\overline{p-1}n}\times u\,.\,\overline{u+m}\,.\,\&c.\ \overline{u+\overline{q-1}m}\times y\,.\,\overline{y+l}\,.\,\&c.$

$\overline{y-\overline{x-1}l}\times\overline{x+o}\,.\,\&c.\ x+\overline{s-1}o\times\,\&c.$ existente 1 Numeratore.

Differentia enim hujus fractionis est fractio cujus numerator est ipsius N valor exhibitus, & denominator idem est ac denominator propositus, ut fieri debuit.

Ex. 1. Sit denominator propositus $z\times\overline{z+2}\times u\times\overline{u+3}$. In hoc casu sunt $n=2$, $m=3$, $p=1$, $q=1$; adeoque est $N=\overline{z+2}\times\overline{u+3}-zu=3z+2u+6$, & per $\frac{3z+2u+6}{z\,.\,\overline{z+2}\times u\,.\,\overline{u+3}}$ repræsentatur terminus Seriei summabilis, cujus nempe in infinitum continuatæ summa exhibetur per $\frac{1}{zu}$. Sint verbi gratiâ, ipsorum z & u primus valor communis 1, atque Series summabilis erit $\frac{1}{1\,.\,3\times1\,.\,4}+\frac{23}{3\,.\,5\times4\,.\,7}+\frac{35}{5\,.\,7\times7\,.\,10}+\&c.$ quippe cujus totius summa est 1.

Per p designetur ordo termini cujusvis in hâc Serie, erit $p=\frac{z-1+2}{2}$, adeoque $z=2p-1$, & $u=3p-2$; quibus valoribus $\frac{u-1+3}{3}$ pro z & u scriptis, designabitur terminus per formulam $\frac{12p-1}{\overline{2p-1}\times\overline{2p+1}\times\overline{3p-2}\times\overline{3p+1}}$. Summa autem terminorum omnium ante terminum illum, hoc est terminorum initialium numero $\frac{z-1}{2}=p-1$, est $1-\frac{1}{zu}$, $=\frac{zu-1}{zu}$, hoc est $\frac{6pp-7p+1}{\overline{2p-1}\times\overline{3p-2}}$.

Quare pro p scripto $p+1$, erit $\frac{p\times\overline{6p+5}}{\overline{2p+1}\times\overline{3p+1}}$ aggregatum tot terminorum initialium quot sunt unitates in p.

Ex. 2. Iiſdem manentibus z, u, n, m, ſit denominator $z \cdot \overline{z+2} \cdot \overline{z+4} \times u \cdot \overline{u+3}$. Tum per formulam numerator erit $\overline{z+4} \times \overline{u+3} - zu = 3z + 4u + 12$, & ſumma Seriei exhibebitur per formulam $\frac{1}{z \cdot \overline{z+2} \times u}$. Sit ipſorum z & u primus valor communis 1, & hinc elicietur Series $\frac{19}{1 \cdot 3 \cdot 5 \times 1 \cdot 4} + \frac{37}{3 \cdot 5 \cdot 7 \times 4 \cdot 7} + \frac{55}{5 \cdot 7 \cdot 9 \times 7 \cdot 10} + \&c. = \frac{1}{3}$.

Scholium. In Seriebus jam expoſitis eadem ubique eſt differentia inter factores continuos ejuſdem cujuſvis termini, ac inter factores homologos terminorum continuorum. In ſequentibus exempla quædam ſunt Serierum, quarum ſummæ in terminis numero finitis exhiberi poſſunt, quamvis ea regula non obſervetur.

Prop. IV. *Prob.*] Creſcente z per differentias datas $q\,n$, invenire numeratorem integrum N, ut ad Integrale revocari poſſit fractio, cujus Denominator fit ex certo numero p terminorum z, $z+n$, $z+2n$, &c. Arithmeticè proportionalium in invicem ductorum. Debet autem eſſe q numerus integer minor quam factorum numerus p.

Solutio. Erit $N = \overline{z+p-1\,n} \times \overline{z+p-2\,n} \times \&c. \times \overline{z+p-q\,n} \times z \times \overline{z+n} \times \&c. \times \overline{z+q-1\,n}$, Integrale exiſtente $\frac{1}{z \times \overline{z+n} \times \&c. \times \overline{z+p-q-1\,n}}$. Demonſtratur ad modum propoſitionis præcedentis.

Sumptis ad libitum n, p, q, & primo valore z, hinc oriuntur infinitæ Series ſummabiles, cujuſmodi ſunt Series tres ſequentes.

$$A = \frac{5}{1.2.3.4} + \frac{9}{3.4.5.6} + \frac{13}{5.6.7.8} + \frac{17}{7.8.9.10} \&c.$$

$$B = \frac{1}{1.2.3.4.5} + \frac{4}{4.5.6.7.8} + \frac{9}{7.8.9.10.11} +$$

+

$$+\frac{16}{10\cdot11\cdot12\cdot13\cdot14}+\&c.$$

$$C=\frac{1}{1\cdot2\cdot3\cdot4\cdot5}+\frac{14}{5\cdot6\cdot7\cdot8\cdot9}+\frac{55}{9\cdot10\cdot11\cdot12\cdot13};$$

$$+\frac{140}{13\cdot14\cdot15\cdot16\cdot17}+\&c.$$

Has Series jampridem communicavi cum primariis quibuſdam Geometris, à quibus minimè contemni videntur. Sic ad me ſcribit peritiſſimus Geometra D. *Nicolaus Bernoulli* in epiſtolâ datâ 25 *Julii* 1716. ‘ Vous me ferez un extreme plaiſir, *Monſieur*, de me communiquer la ‘ Solution de vôtre probleme, *Etant donné une ſuite des Fractions dont* ‘ *les Numerateurs ſoient des nombres figurés quelconque, & dont les Denomi-* ‘ *nateurs ſoient formés du produit d'un nombre egal de Facteurs qui ſoient en* ‘ *Progreſſion Arithmetique, trouver la ſomme*; & principalement comment ‘ vous avez trouvé ces deux formules $\frac{p}{24\times\overline{4p+1}}$, $\frac{p\cdot\overline{p+1}}{12\times\overline{3p+1}\times\overline{3p+2}}$.

Hæ formulæ ſpectant ad Series *C* & *B*, deſignante *p* numerum terminorum, quorum ſumma requiritur. Sic etiam ad me ſcribit D. *Taylor* in epiſtola datâ 22 *Aug.* 1716. ‘ Ut & quâ ratione incidiſti in ſum- ‘ mationem Serierum à te exhibitarum, præſertim loquor de Serie ‘ $\frac{1}{1\cdot2\cdot3\cdot4\cdot5}+\frac{4}{4\cdot5\cdot6\cdot7\cdot8}+\frac{9}{7\cdot8\cdot9\cdot10\cdot11}+$ quæ videtur eſſe altioris idagi nis.

Sed ut ad exempla jam redeamus. In Serie *A* ſunt $p=4$, $q=2$, $n=1$, primo valore z exiſtente 1. Eſt itaque $\overline{z+3}\times\overline{z+2}-z\times\overline{z+1}=2\times\overline{2z+3}$ formula, unde (rejecto dato numero 2) derivantur numeratores 5, 9, 13, 17, *&c.* Formula etiam ſummæ eſt $\frac{1}{z\times\overline{z+1}}$. Quare habitâ ratione numeri 2, quem ex numeratoribus rejecimus, ſumma totius Seriei, à termino in quo eſt z infinitum continuatæ, exhibetur per formulam $\frac{1}{2z\times\overline{z+1}}$; adeoque ſumma Seriei integræ eſt $\frac{1}{2\times1\times2}=\frac{1}{4}$.

In

In Serie *B* ſunt $n = 1$, $p = 5$, $q = 3$, primo valore z exiſtente 1. Eſt itaque $N = \overline{z+4} \times \overline{z+3} \times \overline{z+2} - z \times \overline{z+1} \times \overline{z+2} = 6 \times \overline{z+2}^{2}$. Ipſius autem $\overline{z+2}$ valores continui ſunt 3, 6, 9, *&c.* qui quoniam omnes ſunt diviſibiles per 3, ponendo $z+2 = 3x$, fit $N = 6 \times \overline{3x}|^{2} = 6 \times 9x^{2} = 54x^{2}$, ipſius x valoribus continuis exiſtentibus 1, 2, 3, *&c.* Rejecto itaque numero dato 54, hinc prodeunt numeratores 1, 2^{2}, 3^{2}, *&c.* hoc eſt 1, 4, 9, *&c.* Formula etiam integralis eſt $\frac{1}{z \times \overline{z+1}}$; quare habitâ ratione numeri 54 quem ex numeratoribus rejecimus, ſumma Seriei à termino in quo eſt z in infinitum continuatæ $\frac{1}{54z \times \overline{z+1}}$. Unde ſumma Seriei integræ eſt $\frac{1}{108}$.

In Serie denique *C* ſunt $n = 1$, $p = 5$, $q = 4$. & primus valor $z = 1$. Unde fit $N = \overline{z+4} \times \overline{z+3} \times \overline{z+2} \times \overline{z+1} - z \times \overline{z+1} \times \overline{z+2} \times \overline{z+3} = 4 \times \overline{z+1} \times \overline{z+2} \times \overline{z+3}$. Valores autem N per hanc formulam prodeuntes ſemper poſſunt dividi per $4 \times 2 \times 3 \times 4 = 96$. Ergò hoc diviſore rejecto prodeunt numeratores 1, 14, 55, 140, *&c.*

Et formula Summæ, habitâ ratione numeri 96, eſt $\frac{1}{96z}$. Adeoque Summa Seriei integræ eſt $\frac{1}{96}$.

Scholium 1. Per Propoſitiones has duas noviſſimas nullo negotio inveniri poſſunt Series quot libuerit ſummabiles. Et viciſſim oblatâ Serie hujus ſpeciei, ſi ſummari poteſt, ejus ſumma plerumque revocatur ad alterutram ex his Propoſitionibus. In examine tamen ſolertiâ eſt opus. Optimè autem procedit ſi termini Seriei oblatæ revocentur ad formulam *Prop.* III. Sic *e. gr.* propoſitâ Serie $\frac{7}{3 \cdot 5 \cdot 7 \cdot 9 \cdot 11} + \frac{11}{7 \cdot 9 \cdot 11 \cdot 13 \cdot 15} + \frac{15}{11 \cdot 13 \cdot 15 \cdot 17 \cdot 19} +$ *&c.* Denominatores ſic ſcribi poſſunt $3 \cdot 7 \cdot 11 \times 5 \cdot 9 \cdot 7 \cdot 11 \cdot 15 \times 9 \cdot 13 \cdot 11 \cdot 15 \cdot 19 \times 13 : 17$. *&c.*

Unde

Unde juxta *Prop.* 3. fit $n = 4$, $m = 4$, $p = 2$, $q = 1$, primus valor $z = 3$, primus valor $u = 5$. Hinc formula Numeratoris invenitur $4 \times \overline{z + 2u + 8}$, Eſt autem $z + 2u + 8$ ſemper diviſible per 3; quare rejectis diviſoribus datis 4 & 3, per hanc formulam prodeunt Numeratores 7, 11, 15, *&c.* iidem ac Numeratores in Serie propoſita, quæ proinde ſummabitur per illam propoſitionem.

2. Cùm Series illas *A*, *B*, *C*, communicaveram cum D. *Taylor*, reſcripſit ſe earum ſummas inveniſſe primam quidem *A* & tertiam *C*, eas revocando ad caſus ſimplices Methodi Incrementorum, tertiam *C*, *e. g.*

revocavit ad hanc formam $\frac{1}{24} \times \frac{1}{1 \cdot 5} + \frac{1}{5 \cdot 9} + \frac{1}{9 \cdot 13} + \frac{1}{13 \cdot 17}$ *&c.*

ut habeatur ſumma per præcepta tradita in *Scholio Prop.* 1. In Serie autem ſecundâ *B*, cùm hoc non æquè ſucceſſit, ſequenti uſus eſt Analyſi, quam, ipſius venia jam impetratâ, ob ejus eximiam elegantiam huc transferre non piget ‘ Seriei iſtius terminus [in Stylo ejus] exhibetur per formulam

‘ $\frac{\overline{z + 2} \times z}{27 z \times \overline{z + 1} \times z, \times \overline{z, + 1}}$; pro $z + 3$ in denominatore ſcripto z,

‘ quoniam eſt $z = 3$. Pone $\frac{B}{27 C}$ æquale eſſe Integrali quæſito, hoc eſt

‘ $\frac{B}{C}$ Integrale ipſius $\frac{\overline{z + 2} \times z}{z \cdot \overline{z + 1} \times z, \cdot \overline{z, + 1}}$, ſepoſito diviſore dato 27.

‘ Ipſius autem $\frac{B}{C}$ incrementum eſt $\frac{BC - BC}{CC}$. Debet ergo $\frac{BC - BC}{CC}$

‘ idem eſſe ac $\frac{\overline{z + 2} \times z}{z \cdot \overline{z + 1} \times z, \cdot \overline{z, + 1}}$. Comparando denominatores in-

‘ venitur $C = z \times \overline{z + 1}$. Hinc itaque ſumendo incrementa fit $C =$
‘ $2zz + z^2 + z$ $(= 2zz + 4z,)$ quoniam eſt $z = 3$.) His valoribus
‘ in locum C & C ſubſtitutis prodit $BC - BC = \overline{zz + z} B$
‘ $- 2z \times \overline{z + 2} B$, quod debet eſſe idem ac $\overline{z + 2} \times z$. Sit

$B =$

‘ $B = a + v$, exiſtente a ipſius B parte invariabili, & v parte
‘ variabili. Tum ſumendo incrementa fit $\dot{B} = \dot{v}$. Unde ad in-
‘ venienda a & v habetur æquatio $\overline{zz+z}\,\dot{v} - 2\dot{z} \times \overline{z+2} \times \overline{a+v}$
‘ $= \overline{z+2} \times \dot{z}$, quæ ſic ſcribi poteſt $\overline{z\,z+z}\,\dot{v} - 2\dot{z} \times \overline{z+2}\,\dot{v}$
‘ $= z \times \overline{z+2} \times \overline{1+2}\,a$, vel etiam $C\dot{v} - C\dot{v} = z \times \overline{z+2} \times \overline{1+2}\,a$.

‘ Pone $1 + 2a = 0$ (unde fit $a = \frac{-1}{2}$,) & fit $C\dot{v} - C\dot{v} = 0$; ubi
‘ fieri poteſt $v = 0$, (quoniam æquationis termini ſinguli afficiun-
‘ tur vel ab v, vel ab $\dot{v}$) Hinc ergò fit $B = a = \frac{-1}{2}$, adeoque $\frac{B}{C}$
$= \frac{-1}{2z \times \overline{z+1}}$. Unde habitâ ratione diviſoris 27, Integrale quæſitum
$\frac{-1}{54 \times z \times \overline{z+1}}$. Sed & comparando æquationem $C\dot{v} - C\dot{v} = 0$ cum
‘ formulâ generali $\frac{BC - BC}{CC} = 0$, inde etiam concludere licet eſſe $\frac{v}{C}$
‘ $=$ quantitati datæ, (quoniam ipſius incrementum eſt 0.) Unde pro
‘ n ſumpto quovis numero dato, fit $v = nC$, atque $B = -\frac{1}{2} + nC$.
‘ Quo pacto Integrale quæſitum fit $\frac{B}{C} = \frac{-\frac{1}{2} + nC}{C} = \frac{-1}{2C} + n$,
‘ quod ab Integrali prius invento differt quantitate datâ n. Hoc inde
‘ fit, quod, ut in Quadraturâ Curvarum Area inventa augeri poteſt
‘ vel minui areâ datâ, ſic in Methodo incrementorum Integrale inven-
‘ tum augeri poteſt vel minui quantitate datâ. Per Integrale autem
‘ primum, ubi deeſt n, exhibetur ſumma Seriei in infinitum conti-
‘ nuatæ.

Prop. 5. Creſcente z per unitates, & exiſtentibus a, b, c, &c. numeris datis integris, quorum nullæ inter ſe æquantur; invenire Integrale

ipſius $\frac{1}{z \times \overline{z+a} \times \overline{z+b} \times \overline{z+c} \times \&c.}$

Solutio.

Solutio. Ducendo tam numeratorem quam denominatorem fractionis in terminos $z+1$, $z+2$, &c. $z+a+1$, $z+a+2$, &c. $z+b+1$, $z+b+2$, &c. $z+c+1$, $z+c+2$, &c. in Denominatore deficientes, revocetur Denominator ad formulam $z \times z+1 \times z+2 \times$ &c. Denominatoris in *Prop.* 1. *Schol. n.* 3. Deinde revocetur Numerator ad formam $A+Bz+Cz \times \overline{z+1}+Dz \times \overline{z+1} \times \overline{z+2}+$ &c. Tum applicando terminos ad Denominatorem novum $z \times \overline{z+1} \times \overline{z+2} \times$ &c. revocetur fractio ad hanc formam $\frac{A}{z \times \overline{z+1} \times \text{&c.}} + \frac{B}{\overline{z+1} \times \overline{z+2} \times \text{&c.}} + \frac{C}{\overline{z+2} \times \overline{z+3} \times \text{&c.}} + \frac{D}{\overline{z+3} \times \overline{z+4} \times \text{&c.}}$ &c. Unde denique quæratur Integrale per *Schol. Prop.* 1. *n.* 3.

Ratio Solutionis per ſe ſatis eſt manifeſta.

Scholium 1. Hujus Solutionis tota difficultas latet in revocatione Numeratoris ad formam requiſitam, quod tamen quomodo ſit faciendum uno exemplo patebit. Proponatur itaque factum $\overline{z+2} \times \overline{z+3} \times \overline{z+7}$, quod ad formam propoſitam ſit revocandum. Terminos itaque evolvo gradatim ut ſequitur. Factorem primum $z+2$ ſic ſcribo $2+z$, cujus terminum primum 2 duco in $3+z$, unde fit $6+2z$: Terminum ſecundum z duco in $2+\overline{z+1}$ $(=\overline{z+3})$ unde fit $2z+z \times \overline{z+1}$. Dein facta in unam ſummam colligendo, fit $\overline{\overline{z+2} \times \overline{z+3}} = \begin{matrix} 6+2z \\ +2z \end{matrix} + z \times \overline{z+1} = 6+4z+z \times \overline{z+1}$. Supereſt ut hoc ducatur in $z+7$. Itaque terminum primum 6 duco in $7+z$ $(=z+7)$ unde fit $42+6z$; terminum ſecundum $4z$ duco in $6+\overline{z+1}$ $(=z+7)$ unde fit $24z+4z \times \overline{z+1}$; terminum tertium $z \times \overline{z+1}$ duco in $5+\overline{z+2}$ $(=z+7,)$ unde fit $5z \times \overline{z+1}+z \times \overline{z+1} \times \overline{z+2}$. Factis itaque in unum collectis ut prius, fit $\overline{z+2} \times \overline{z+3} \times \overline{z+4} = 42+30z+9z \times \overline{z+1}+z \times \overline{z+1} \times \overline{z+2}$. Et ad eundem modum procedere licet in aliis caſibus.

2. Sit

2. Sit autem exemplum Propositionis in Fractione $\frac{1}{z \times \overline{z+2} \times \overline{z+5}}$.

Restituendo factores $\overline{z+1}$, $\overline{z+3}$, $\overline{z+4}$ in Denominatore deficientes, Fractio fit $\frac{\overline{z+1} \times \overline{z+3} \times \overline{z+4}}{z \times \overline{z+1} \times \overline{z+2} \times \overline{z+3} \times \overline{z+4} \times \overline{z+5}}$. Revocandus itaque est Numerator $\overline{z+1} \times \overline{z+3} \times \overline{z+4}$ ad Formam requisitam. Itaque per Methodum jam traditam fit primo $\overline{z+1} \times \overline{z+3} = 1 \times \overline{3+z} + z \times 2 + \overline{z+1} = 3 + \overline{z+2}z + z \times \overline{z+1} = 3 + 3z + z \times \overline{z+1}$. Deinde $\overline{z+1} \times \overline{z+3} \times \overline{z+4} = 3 \times \overline{4+z} + 3z \times \overline{3+z+1} + z \times \overline{z+1} \times \overline{2+z+2} = 12 + 3z + 9z + 3z \times \overline{z+1} + \overline{2z \times \overline{z+1}} + z \times \overline{z+1} \times \overline{z+2} = 12 + 12z + 5z \times \overline{z+1} + z \times \overline{z+1} \times \overline{z+2}$. Applicando hoc factum ad Denominatorem $z \times \overline{z+1} \times$ &c. $\times \overline{z+5}$ Fractio tandem revocatur ad hanc Formam

$$\frac{12}{z \times \overline{z+1} \times \overline{z+2} \times \overline{z+3} \times \overline{z+4} \times \overline{z+5}}$$

$$+ \frac{12}{\overline{z+1} \times \overline{z+2} \times \overline{z+3} \times \overline{z+4} \times \overline{z+5}}$$

$$+ \frac{5}{\overline{z+2} \times \overline{z+3} \times \overline{z+4} \times \overline{z+5}} + \frac{1}{\overline{z+3} \times \overline{z+4} \times \overline{z+5}}$$

Cujus denique Integrale est $\frac{-12}{5z \times \overline{z+1} \times \overline{z+2} \times \overline{z+3} \times \overline{z+4}}$ +

$$+\frac{-12}{4.\overline{z+1}\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}}+\frac{-5}{3.\overline{z+2}\times\overline{z+3}\times\overline{z+4}}$$

$$\frac{-1}{2.\overline{z+3}\times\overline{z+4}}.$$

3. Quando duo tantùm ſunt Factores z & $z+a$, exhibebitur etiam Integrale per formulam $\frac{1}{2}-\frac{1-a}{2z\times\overline{z+1}}-\frac{\overline{1-a}\times\overline{2-a}}{3z\times\overline{z+1}\times\overline{z+2}}$

$$-\frac{\overline{1-a}\times\overline{2-a}\times\overline{3-a}}{4z\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}}\ \&c.$$

Seriem nempe continuando donec abrumpatur per evaneſcentiam terminorum. Si Factores duo ſint z & $z-a$ exhibebitur Integrale per formulam $\frac{-1}{z-1}-\frac{-1+a}{2.\overline{z-1}.\overline{z-2}}$

$$-\frac{-1+a\times-2+a}{3.\overline{z-1}.\overline{z-2}.\overline{z-3}}-\&c.$$

Poteſt idem Integrale exprimi utroque modo, prout fractionis oblatæ Factor vel minor vel major ſumatur pro z.

4. Si primus valor z ſit $a+1$, migrabit formula poſterior in hanc

$$\frac{-1}{a}\times\frac{1}{1}\times\frac{1}{2}\times\frac{1}{3}+\&c.\ \text{uſque}\ \frac{1}{a}\ \text{incluſivè,}$$

quâ, cum ſigno contrario, exhibetur ſumma Seriei $\frac{1}{1\times\overline{1+a}}+\frac{1}{2\times\overline{2+a}}+\frac{1}{3\times\overline{3+a}}+$ &c. in infinitum continuatæ. Sit *e. gr.* $a=1$, atque Series erit

$$\frac{1}{1\times2}+\frac{1}{2\times3}+\frac{1}{3\times4}+\&c.=\frac{1}{1}\times\frac{1}{1}=1.$$

Si $a=2$, erit Series

$$\frac{1}{1\times3}+\frac{1}{2\times4}+\frac{1}{3\times5}+\&c.=\frac{1}{2}\times\frac{1}{1}+\frac{1}{2}=\frac{3}{4};$$

Si $a=3$, Series erit

erit $\frac{1}{1\times4}+\frac{1}{2\times5}+\frac{1}{3\times6}+\frac{1}{4\times7}$ &c. $=\frac{1}{3}\times\frac{1}{1}+\frac{1}{2}+\frac{1}{3}=\frac{11}{18}$.

5. Ex eâdem Serie $\frac{1}{1\times1+a}+\frac{1}{2\times2+a}+\frac{1}{3\times3+a}+$ &c. pro diverſo valore *a* oriuntur Series plures formâ ſatis elegantes, quarum nonnullas Lectori ob oculos ſiſtere, credo, ingratum non erit.

Si pro *a* ſumantur ſucceſſivè numeri pares, 2, 4, 6, 8, &c. Series erunt

Si $a=2$) $\frac{1}{1\times1+2}+\frac{1}{2\times2+2}+\frac{1}{3\times3+2}+\frac{1}{4\times4+2}+$ &c.

4) $\frac{1}{1\times1+4}+\frac{1}{2\times2+4}+\frac{1}{3\times3+4}+\frac{1}{4\times4+4}+$ &c.

6) $\frac{1}{1\times1+6}+\frac{1}{2\times2+6}+\frac{1}{3\times3+6}+\frac{1}{4\times4+6}+$ &c.

8) $\frac{1}{1\times1+8}+\frac{1}{2\times2+8}+\frac{1}{3\times3+8}+\frac{1}{4\times4+8}+$ &c.

Vel $\frac{1}{4-1}+\frac{1}{9-1}+\frac{1}{16-1}+\frac{1}{25-1}+$ &c.

$\frac{1}{9-4}+\frac{1}{16-4}+\frac{1}{25-4}+\frac{1}{36-4}+$ &c.

$\frac{1}{16-9}+\frac{1}{25-9}+\frac{1}{36-9}+\frac{1}{49-9}+$ &c.

$\frac{1}{25-16}+\frac{1}{36-16}+\frac{1}{49-16}+\frac{1}{64-16}+$ &c.

Vel $\frac{1}{4-1}+\frac{1}{9-1}+\frac{1}{16-1}+\frac{1}{25-1}+$ &c.

$\frac{1}{4+1}+\frac{1}{9+3}+\frac{1}{16+5}+\frac{1}{25+7}+$ &c.

$$\frac{1}{4+3}+\frac{1}{9+7}+\frac{1}{16+11}+\frac{1}{25+15}+\&c.$$

$$\frac{1}{4+5}+\frac{1}{9+11}+\frac{1}{16+17}+\frac{1}{25+23}+\&c.$$

Si pro a ſumantur ſucceſſivè numeri impares, 1, 3, 5, 7, &c. Series erunt

$a=1)\ \frac{1}{1\times 1+1}+\frac{1}{2\times 2+1}+\frac{1}{3\times 3+1}+\frac{1}{4\times 4+1}+\&c.$

$3)\ \frac{1}{1\times 1+3}+\frac{1}{2\times 2+3}+\frac{1}{3\times 3+3}+\frac{1}{4\times 4+3}+\&c.$

$5)\ \frac{1}{1\times 1+5}+\frac{1}{2\times 2+5}+\frac{1}{3\times 3+5}+\frac{1}{4\times 4+5}+\&c.$

$7)\ \frac{1}{1\times 1+7}+\frac{1}{2\times 2+7}+\frac{1}{3\times 3+7}+\frac{1}{4\times 4+7}+\&c.$

Vel $\frac{1}{2}\times\frac{1}{1}+\frac{1}{3}+\frac{1}{6}+\frac{1}{10}+\&c.$

$\frac{1}{2}\times\frac{1}{3-1}+\frac{1}{6-1}+\frac{1}{10-1}+\frac{1}{15-1}+\&c.$

$\frac{1}{2}\times\frac{1}{6-3}+\frac{1}{10-3}+\frac{1}{15-3}+\frac{1}{21-3}+\&c.$

$\frac{1}{2}\times\frac{1}{10-6}+\frac{1}{15-6}+\frac{1}{21-6}+\frac{1}{28-6}+\&c.$

Vel $\frac{1}{2}\times\frac{1}{1+0}+\frac{1}{3+0}+\frac{1}{6+0}+\frac{1}{10+0}+\&c.$

$\frac{1}{2}\times\frac{1}{1+1}+\frac{1}{3+2}+\frac{1}{6+3}+\frac{1}{10+4}+\&c.$

$\frac{1}{2}\times\frac{1}{1+2}+\frac{1}{3+4}+\frac{1}{6+6}+\frac{1}{10+8}+\&c.$

$-x$

$$\frac{1}{2} \times \frac{1}{1+3} + \frac{1}{3+6} + \frac{1}{6+9} + \frac{1}{1+12} + \&c.$$

6. Ante aliquot annos D. *Jac. Bernoulli* Geometra inſignis invenit ſummam Seriei cujuſlibet, cujus Numeratores conſtituunt Seriem æqualium, Denominatores verò conſtituunt, vel Seriem quadratorum dato aliquo quadrato $\mathcal{Q}$ minutorum, vel Seriem Triangulorum, dato aliquo Triangulo $\mathcal{T}$ minutorum. Hæc invenit ille obſervando quod hujuſmodi Series oriantur ex ablatione Seriei harmonicè proportionalium truncatæ ab eâdem Serie integrâ ; nempe ita ut numerus terminorum deficientium in Serie truncata, ſit, vel duplus lateris dati quadrati $\mathcal{Q}$, vel duplus unitate auctus lateris dati Trianguli $\mathcal{T}$. Idem etiam obſervavit fruſtrà quæri ſummam Seriei reciprocæ Quadratorum. Hoc idem etiam verum eſt de reciprocis Cuborum, vel aliarum quarumlibet dignitatum numerorum in Progreſſione Arithmeticâ. Ratio eſt, quòd nulla intercedit differentia inter Factores Denominatorum, quod ad hujuſmodi ſummationes ſemper requiri conſtat ex Methodo ſumendi differentias in *Scholio Prop.* I. jam explicatâ. Nam ſi per formulam aliquam exhiberi poſſet ſumma quæſita, differentia iſtius formulæ exhiberet terminos Seriei propoſitæ : ſed in tali differentiâ denominator ſemper afficitur per factores ab invicem diverſos, quod quoniam in Seriebus prædictis non obtinet, ſummæ Serierum hujuſmodi in terminis finitis haberi nequeunt. Ad eundem ferè modum, argumento petito à *Prop.* III. & IV. demonſtrari poteſt ſummas Serierum exhiberi non poſſe in terminis numero finitis, quarum Numeratores conſtituunt Seriem æqualium. Denominatores vero conſtant ex certo numero terminorum in Progreſſione Arithmetica, maximo factore cujuſvis termini minore exiſtente quàm factor minimus in termino proximè inſequenti, cujuſmodi eſt Series

$$\frac{1}{1 \cdot 2} + \frac{1}{3 \cdot 4} + \frac{1}{5 \cdot 6} + \&c.$$

7. Jam liceret Regulas nonnullas tradere quas pro caſibus quibuſdam ſingularibus concinnavi ; ſed hæc nos longius abducerent. Sufficiat itaque quæ generaliora ſunt explicaſſe, & ſimul monuiſſe, ad novæ hujuſce Serierum infinitarum doctrinæ provectionem nihil magis facere, quam ſi excogitentur Formulæ generaliores ſummarum, ex quarum differentiis, per Regulas ſupra traditas computatis, deinde conficiantur Canones quantitatum ſummabilium ; ita ferè ut jam factum eſt in Calculo Integrali, *h. e.* in Stylo *Newtoniano*, in Methodo Fluxionum.

8. Reſtituendo Factores in Denominatore deficientes potuiſſet præſens Problema revocari ad *Propoſitionem* II. Sed & in terminis generalioribus proponi poteſt, nempe pro Numeratore ſumpta quavis Formula, cujus differentia aliqua datur. Sub eâ tamen conditione ut dimenſiones Denominatoris ad minimum binario ſuperent Dimenſiones Numeratoris; aliàs enim ſumma Seriei in terminis numero finitis haberi

beri nequit. Sit hujus rei exemplum in Serie $\frac{1}{1\cdot3\cdot5\cdot7} + \frac{4}{2\cdot4\cdot6\cdot8} + \frac{9}{3\cdot5\cdot7\cdot9} + \frac{16}{4\cdot6\cdot8\cdot10} +$ &c. ubi Numeratores ſunt numerorum naturalium quadrata. Applicando tum Numeratores tum Denominatores ad numeros naturales, Series revocatur ad formam ſimpliciorem $\frac{1}{3\cdot5\cdot7} + \frac{2}{4\cdot6\cdot8} + \frac{3}{5\cdot7\cdot9} + \frac{4}{6\cdot8\cdot10} +$ &c.

Per p deſignatis numeris naturalibus 1, 2, 3, 4, &c. terminus Seriei deſignabitur per formulam $\frac{p}{\overline{p+2}\times\overline{p+4}\times\overline{p+6}}$; vel per formulam $\frac{z-2}{z\times z+2\times z+4}$, nempe pro $p+2$ ſcripto z. Quoniam progrediendo de termino in terminum augetur z per unitates, reſtituendi ſunt Factores in Denominatore deficientes $z+1$, $z+3$, & hoc pacto revocatur terminus Seriei ad formulam $\frac{\overline{z-2}\times\overline{z+1}\times\overline{z+3}}{z\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}}$

Per methodum in hâc Propoſitione jam explicatam revocatur Numerator ad formam $-6-6z-z\times\overline{z+1}+z\times\overline{z+1}\times\overline{z+2}$. Unde habita ratione Denominatoris Terminus revocatur ad formam

$$+\frac{-6}{z\times\overline{z+1}\times\&c.\times\overline{z+4}}+\frac{-6}{\overline{z+1}\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}}$$
$$+\frac{-1}{\overline{z+2}\times\overline{z+3}\times\overline{z+4}}+\frac{1}{\overline{z+3}\times\overline{z+4}}.$$

Adeoque ſumendo Integrale fit

$$\frac{6}{4z\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}}+\frac{6}{3\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}}$$
$$+\frac{1}{2\times\overline{z+2}\times\overline{z+3}}+\frac{-1}{z+3}+1;$$

quo, ſub ſigno contrario, exhibetur

ſumma

ſumma Seriei in infinitum continuatæ, incipientis à termino $\frac{z-2}{z \times \overline{z+2} \times \overline{z+4}}$. Summa itaque Seriei integræ incipientis à termino $\frac{1}{3 \cdot 5 \cdot 7}$ eſt $\frac{31}{240}$.

Si per *Prop.* II. procedere eſſet animus, ex formula $\overline{z-2} \times \overline{z+1} \times \overline{z+3}$ collectis Numeratoribus primis 24, 70, 144, 252, ſumendo eorum differentias haberentur $46 = b$, $28 = c$, $6 = d$, $e = 0 = \&c.$ exiſtente $M = 24$; unde per *Lem.* 2. prodiret formula $-6-6z-z \times \overline{z+1} + z \times \overline{z+1} \times \overline{z+2}$, qua deſignatur Terminus, eadem ac ſupra; atque pergendo per *Prop.* II. haberetur ſumma.

Prop. VI. *Prob.*] Invenire ſummam quotlibet terminorum Seriei Fractionum, quarum Numeratores & Denominatores conſtituunt lineas duas quaſvis tranſverſas in Triangulo Arithmetico *Paſchalii*; nempe cujus generatores ſunt unitates.

Solutio. Per n deſignetur Ordo Seriei Numeratorum in Triangulo Arithmetico, & ſit p differentia inter ordinem Numeratorum & Denominatorum, & per q deſignetur numerus terminorum quorum ſumma requiritur. Tum ſi Denominatores ſint plurium dimenſionum quàm ſunt Numeratores, Summa exhibebitur per formulam primam ſequentem; ſi dimenſiones Numeratorum plures ſint quàm dimenſiones Denominatorum, Summa exhibebitur per formulam ſecundam.

Formula I.

$$\frac{n+p-1}{p-1} - \frac{n \cdot \overline{n+1} \cdot \overline{n+2} \cdot \&c. \overline{n+p-1}}{\overline{p-1} \times \overline{n+q} \cdot \overline{n+q+1} \cdot \&c. \overline{n+q+p-2}}$$

Formula II.

$$-\frac{n-p-1}{p+1} + \frac{\overline{q+n-1} \cdot \overline{q+n-2} \cdot \&c. \overline{q+n-p-1}}{\overline{p+1} \times \overline{n-1} \cdot \overline{n-2} \cdot \&c. \overline{n-p}}$$

Ex. 1. Inveniendum ſit aggregatum ſex primorum terminorum Seriei $\frac{1}{1} + \frac{4}{7} + \frac{10}{28} + \frac{20}{84} + \frac{35}{210} + \frac{56}{462} + \&c.$ ubi Numeratores conſtituunt lineam quartam, Denominatores conſtituunt ſeptimam in Triangulo Arithmetico,

metico. Sunt itaque $n=4, p=3, q=6$; & quoniam dimenſiones Denominatorum ſuperant dimenſiones Numeratorum, dabitur ſumma per Formulam primam; nempe $\frac{4+3-1}{3-1} - \frac{4\cdot5\cdot6}{\overline{3-1}\times\overline{4+6}\times\overline{4+7}}$ ſive $3-\frac{6}{11}=2\frac{5}{11}$,

Ex. 2. Quæratur ſumma ſex primorum terminorum Seriei $\frac{1}{1}+\frac{7}{4}+\frac{28}{10}+\frac{84}{20}+\frac{210}{35}+\frac{462}{56}+$ &c. cujus termini ſunt terminorum Seriei prioris reciproci. Sunt itaque $n=7$, $p=3$, $q=6$, adeoque per Formulam ſecundam ſumma fit $-\frac{3}{4}+\frac{12\cdot11\cdot10\cdot9}{4\times6\cdot5\cdot4}=24$.

Scholium 1. Formulas in hâc Propoſitione exhibitas ante biennium communicavi cum Viris celeberrimis *Moivreo* & *Bernoulliis*. Facile autem derivari poſſunt ex præceptis in *Prop.* I. traditis. Sit exemplum in Serie priori $\frac{1}{1}+\frac{4}{7}+\frac{10}{28}+$ &c. Per p deſignato loco Termini in Serie hâc, exhibetur Terminus per Formulam $\frac{4\cdot5\cdot6}{\overline{p+3}\cdot\overline{p+4}\cdot\overline{p+5}}$; Unde regrediendo ad Integrale, ſumma Seriei incipientis à termino illo exhibetur per Formulam $\frac{4\cdot5\cdot6}{2\times\overline{p+3}\times\overline{p+4}}$; adeoque pro p ſumpto 1, Series integra fit $\frac{4\cdot5\cdot6}{2\cdot4\cdot5}=3$ atque Summa primorum ſex terminorum fit $3-\frac{4\cdot5\cdot6}{2\cdot10\cdot11}$, omninò ut per Formulam jam exhibetur.

2. In Formulâ primâ ſumma Seriei in infinitum continuatæ eſt $\frac{n+p-1}{p-1}$, evaneſcente jam parte altera Formulæ. Sed in caſu Formulæ ſecundæ ſumma hæc eſt infinitum quid, cujus ſpecies, reſpectu numeri infiniti q, exhibetur per Formulæ partem alteram, quæ in hoc caſu fit $\frac{q^{p+1}}{p+1\times\overline{n-1}\cdot\overline{n-2}\cdot\&c.\,\overline{n-p}}$.

3. De

3. De hujuſmodi Seriebus in epiſtolâ datâ menſe *Maio* 1716, ſic ad me ſcripſit Vir. Ill. *D. Leibnitius*, quem magno Scientiarum damno nobis nuper ereptum lugemus. ‘ Il me ſemble qu'autrefois j'ay auſſi

‘ ſommé quelques Series ou ſuites comme $\frac{1}{1} + \frac{2}{4} + \frac{3}{10} + \frac{4}{20} + \frac{5}{35}$

‘ $+ \frac{6}{56} +$ &c. Le terme de cette ſuite exprimé Analytiquement eſt

‘ $\frac{x}{x \cdot \overline{x+1} \cdot \overline{x+2} \times \frac{1}{1} \cdot \frac{1}{2} \cdot \frac{1}{3}} = \frac{1 \cdot 2 \cdot 3}{\overline{x+1} \cdot \overline{x+2}} = \frac{6}{xx+3x+2}$. On

‘ demande donc la ſomme d'une ſuite donnée, dont un terme ſoit

‘ $\frac{ll}{xx+3lx+2ll}$ ou x ſignifie les nombres naturales 1, 2, 3, 4, &c.

‘ & l ſignifie l'Unité, ou la difference des x. Suppoſons que le

‘ terme de la ſuite ſommatrice demandé ſoit $\frac{fx}{mx+nl} = \frac{\odot}{\mathfrak{D}}$.

‘ Or Diff. $\frac{\odot}{\mathfrak{D}} = -\frac{\odot}{\mathfrak{D}} + \frac{\odot + d\odot}{\mathfrak{D} + d\mathfrak{D}} = \frac{\mathfrak{D}\, d\odot - \odot\, d\mathfrak{D}}{\mathfrak{D}\,\mathfrak{D} + \mathfrak{D}\, d\mathfrak{D}}$: ſed $d\odot =$

‘ fdx, & $d\mathfrak{D} = m\,dx = ml$ donc la Difference de $\frac{\odot}{\mathfrak{D}}$ eſt

‘ $= \frac{nfll}{mmxx + 2mnlx + nnll + mmlx + mnll}$. Maintenant il faut faire

‘ $\frac{nfll}{mmxx + 2mnlx + nnll + mmlx + mnll} = \frac{mfll}{mmxx + 3mmlx + 2mmll}$

‘ c'eſt a dire, il faut identifier ces deux Formules, ou la donnée eſt mul-

‘ tipliée per $\frac{nf}{mm}$: donc égalant les termes reſpectifs, puiſque les xx

‘ conviennent, on aura par les x, $2n + m = 3m$, c'eſt a dire il y aura
‘ $m = n$, & par les abſolus on aura $nn + mn = 2mm$, ce qui donne en-
‘ core $m = n$; donc l'identification reuſſit & nous pouvons faire $n = m =$
‘ $l = 1$, & $f = 1$ (car f demeure arbitraire) & le terme de la ſuite ſom-

‘ matrice ſera $\frac{x}{x+1}$, car diff. $\frac{x}{x+1}$ donne $-\frac{x}{x+1} + \frac{x+1}{x+2}$

‘ $= \frac{1}{xx+3x+2}$, & par conſequente $\frac{6x}{x+1}$ donne la ſomme des

‘ $\frac{2}{x \cdot \overline{x+1} \cdot \overline{x+2} \times \frac{1}{1} \cdot \frac{1}{2} \cdot \frac{1}{3}}$ 3, 4, $\frac{9}{2}$, $\frac{24}{5}$, 5, $\frac{36}{7}$, *&c. Series ſumma-*

‘ *trix, cujus terminus* $\frac{6x}{x+1}$.

‘ $\frac{1}{1} + \frac{2}{4} + \frac{3}{10} + \frac{4}{20} + \frac{5}{35}$ *&c. Series ſummanda, cujus terminus*

‘ $\frac{x}{x \cdot x+1 \cdot x+2 \times \frac{1}{1} \times \frac{1}{2} \cdot \frac{1}{3}}$. Et pour s'en ſervir aux ſommations,

‘ les 5 termes, *par Ex.* de la ſuite donnée ſeront $\frac{36}{7} - 3 = \frac{15}{7}$. Et

‘ generalement la ſomme des termes juſqu'a quelque terme

‘ $\frac{x}{x \cdot \overline{x+1} \cdot \overline{x+2} \times \frac{1}{2} \cdot \frac{1}{1} \cdot \frac{1}{3}}$ excluſivement, ſera $\frac{6x}{x+1} - 3$: Et

‘ pour la ſomme de la ſuite entiere a l'infinie, x devient infini, &

‘ $\frac{6x}{x+1} = 6$: donc la ſomme de toute la ſuite eſt $6 - 3 = 3$, comme

‘ vous l'avez trouvé.

‘ Cette methode eſt le calcul des differences appliqué aux Nom-
‘ bres ; & il faut vous avouer qu'avant que de l'appliquer aux Figures,
‘ & même avant que d'avoir été Geometre, Je le prattiquai en quel-
‘ que façon dans les nombres ; ayant trouvé encore jeune garçon que
‘ les ſuites dont les Numerateurs fuſſent des Unites, & dont les De-
‘ nominateurs fuſſent les Nombres figurés, comme Triangulaires Pyra-
‘ midaux, *&c.* étoient les differences 1^eres^, 2^es^, 3^emes^, *&c.* multipliées

‘ par les conſtantes de la ſuite $\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4}$ *&c.* & par

‘ conſequent ſommables. Mais quand je devins un peu Geometre &
‘ Analyſte, Je vis qu'il y avoit moyen de venir a bout de telles ſomma-
‘ tions par une Methode generale, autant qu'il étoit poſſible ; & que
‘ le calcul des differences êtoit encore plus commode dans la Geome-
‘ trie que dans les Nombres, puis qu'il y a plus d'evanouiſſements, &
‘ que les differences repondent aux Tangentes, les ſommes aux Qua-
‘ dratures. Cette methode generale de chercher la ſuite ſommatrice

‘ de la ſuite donnée, quand elle eſt poſſible, reuiſſit toujours, quand ‘ le terme de la ſuite donnée exprimé Analytiquement n'a point la ‘ quantité variable enveloppé dans une racine, n'y entrant dans l'expo- ‘ ſant; & alors, on peut toujours determiner la ſuite ſommatrice, ou ‘ prouver qu'il eſt impoſſible d'en trouver. Et la choſe reuſſit même ‘ bien ſouvent, lors même que la variable entre dans l'expoſant. Mais ‘ comme elle y a quelquefois des Quadratures particulieres de quelques ‘ portions d'une Figure, dont ou ne ſçauroit donner la Quadrature ‘ generale ou la Figure quadratice; de même on peut trouver quelque- ‘ fois la ſomme de toute la ſuite, ou d'un certaine partie, quoy ‘ qu'on ne puiſſe pas trouver la ſomme de chaque partie; & alors il ‘ faut avoir recours a des Methodes particulieres, dont on n'eſt pas ‘ toujours le maître, nôtre Analyſe n'étants pas encore portée a ſa ‘ perfection.’

Prop. VII. *Prob.*] Invenire ſummam Seriei cujus Numeratores conſtituunt lineam quamlibet erectam in Triangulo Arithmetico *Paſchalii*, Denominatores vero conſtituunt lineam quamlibet tranſverſam.

Solutio. Deſignetur ordo lineæ erectæ per p, ordo lineæ tranſverſæ per q, & ſit m aggregatum tot terminorum primorum in lineâ erectâ ordinis $p+q-1$ quot ſunt unitates in $q-1$, atque ſumma quæſita

$$\text{erit } \overline{2^{p+q-2}} - m \times \frac{1 \cdot 2 \cdot 3 \cdot \&c. \overline{q-1}}{p \cdot \overline{p+1} \cdot \&c. \overline{p+q-2}}.$$

Ex. 1. Proponatur Series $\frac{1}{1} + \frac{5}{4} + \frac{10}{10} + \frac{10}{20} + \frac{5}{35} + \frac{1}{56}$. Ubi Numeratores conſtituunt lineam ſextam erectam, Denominatores occupant lineam quartam tranſverſam. In hoc itaque caſu ſunt, $p = 6$, $q = 4$, $p+q-1 = 9$, $q-1 = 3$, adeoque $m = 1 + 8 + 28 = 37$ *i. e.* tribus terminis primis lineæ nonæ erectæ. Unde fit ſumma quæſita

$$\overline{2^8 - 37} \times \frac{1 \cdot 2 \cdot 3}{6 \cdot 7 \cdot 8} = \frac{219}{56}.$$

Ex. 2. Conſtituant Numeratores lineam centeſimam erectam, & ſint Denominatores Numeri Trigonales, qui occupant lineam tertiam tranſverſam. Tum erunt $p = 100$, $q = 3$, $m = 102$ atque adeo ſumma quæſita fit $\overline{2^{101} - 102} \times \frac{1 \cdot 2}{100 \cdot 101}$.

Cor. Si $q = 2$, formula fit $\frac{2^p - 1}{p}$, quâ exhibetur aggregatum primi

termini, unà cum ſemiſſe ſecundi, triente tertii, quadrante quarti, & ſic porrò, lineæ cujuſvis erectæ ordinis p Trianguli Arithmetici *Paſchalii.*

Sic *v. gr.* eſt $\frac{1}{1} + \frac{5}{2} + \frac{10}{3} + \frac{10}{4} + \frac{5}{5} + \frac{1}{6} = \frac{2^6 - 1}{6} = 10\frac{1}{2}$.

Prop. VIII. *Prob.*] Invenire ſummam ejuſdem Seriei, quando terminorum ſigna ſunt alternatim + & —.

Solutio. Summa quæſita exhibetur per Formulam ſimpliciſſimam $\frac{q-1}{p+q-2}$.

Ex. Invenienda ſit ſumma Seriei $\frac{1}{1} - \frac{6}{9} + \frac{15}{45} - \frac{20}{165} + \frac{15}{495} - \frac{6}{1287} + \frac{1}{3003}$, ubi Numeratores conſtituunt Lineam ſeptimam erectam, Denominatores conſtituunt nonam tranſverſam. In Formula itaque pro p & q ſcriptis 7 & 9, fit ſumma $\frac{8}{14}$.

Manente eadem Serie Numeratorum (nempe lineâ ſeptimâ erectâ,) ſi pro Serie Denominatorum ſumantur ſucceſſivè lineæ tranſverſæ 2^{da}, 3^{tia}, 4^{ta}, *&c.* Summæ erunt $\frac{1}{7}$, $\frac{2}{8}$, $\frac{3}{9}$, $\frac{4}{10}$, $\frac{5}{11}$, *&c.* quæ ſic poſſunt ſcribi, $\frac{1}{7}$, $\frac{7}{28}$, $\frac{28}{84}$, $\frac{84}{210}$, $\frac{210}{462}$, *&c.* ubi tam Numeratores, quàm Denominatores excerpuntur ex lineâ tranſversâ ordinis ſeptimi. Idem eveniret ſi loco ſeptimæ, Numeratores conſtituiſſent aliam quamlibet Lineam erectam Ordinis p; Summæ quippe orirentur ex Applicatione terminorum Lineæ tranſverſæ ejuſdem Ordinis p ad terminos proximè ſequentes in eadem Linea.

Propoſitiones hæ duæ noviſſimæ potius elegantes ſunt quàm utiles; quare Formularum noſtrarum Demonſtrationem Lectoris ſolertia inveſtigandam relinquimus, ad Propoſitionem ultimam jam properantes, quæ tertiam continet Serierum Speciem, ob uſum multiplicem ſatis inſignem.

Lemma 5.] Sit Series quævis $\frac{M}{b}$, $\frac{N}{b^2}$, $\frac{O}{b^3}$, $\frac{P}{b^4}$, *&c.* cujus terminorum Denominatores conſtituunt Progreſſionem quamlibet Geometricam b, b^2, b^3, b^4, *&c.* Sint etiam Numeratorum primus A ($= M$,) prima Differentiarum primarum B, prima ſecundarum C, prima tertiarum

rum *D*, quartarum *E*, & ſic porrò; & ſint $\frac{\alpha}{b}$, $\frac{\beta}{b^2}$, $\frac{\gamma}{b^3}$, $\frac{\delta}{b^4}$, *&c.* reſpectivè, aggregata, Unius, Duorum, Trium, Quatuor, vel plurium terminorum Seriei $\frac{M}{b}$, $\frac{N}{b^2}$, $\frac{O}{b^3}$, *&c.* atque ſint Numeratorum primus *a* (= α) prima Differentiarum primarum *b*, prima ſecundarum *c*, prima tertiarum *d*, & ſic porrò: & ſit $b-1=q$. Tum ipſorum *a*, *b*, *c*, *d*, *&c.* valores erunt.

$a = A = \alpha = M$
$b = bA + B$
$c = qbA + bB + C$
$d = q^2bA + qbB + bC + D$
& ſic porrò.

Demonſtratio.] Satis conſtat eſſe $a = \alpha = A = M$.

Termini $\frac{M}{b}$, $\frac{N}{b^2}$, $\frac{O}{b^3}$, $\frac{P}{b^4}$, *&c.* Numeratoribus *M*, *N*, *O*, *P*, *&c.* expreſſis per *A*, *B*, *C*, *D*, *&c.* transformantur in terminos $\frac{A}{b}$, $\frac{A+B}{b^2}$, $\frac{A+2B+C}{b^3}$, $\frac{A+3B+3C+D}{b^4}$ *&c.* Unde colligendo ſummas terminorum, inveniuntur Numeratores α, β, γ, δ, *&c.* nempe

$\alpha = A$
$\beta = \overline{b+1}A + B$
$\gamma = \overline{b^2+b+1}A + \overline{b+2}B + C$
$\delta = \overline{b^3+b^2+b+1}A + \overline{b^2+2b+3}B + \overline{b+3}C + D$, *&c.*

Unde ſumendo differentias fiunt

$b = bA + B$
$c = qbA + bB + C$
$d = qqbA + qbB + bC + D$

& ſic porrò, ut in Propoſitione exhibentur.

Cor. 1. Si Numeratorum *M*, *N*, *O*, *P*, *&c.* Differentia vel prima, vel ſecunda, vel alia quædam detur, terminis omnibus poſt primos aliquot in Serie *A*, *B*, *C*, *D*, *&c.* evaneſcentibus Differentiæ *b*, *c*, *d*, *&c.* tandem incurrent in Progreſſionem Geometricam in ratione 1 ad *q*. Exempli gratiâ, ſi detur Numeratorum *M*, *N*, *O*, *P*, *&c.* Differentia prima *B*, erunt *c*, *d*, *&c.* in ratione continuâ Geometricâ 1 ad *q*; ut conſtat per ipſorum valores $qbA + bB$, $qqbA + qbB$, *&c.* exiſtentibus $C = 0 = D =$ *&c.*

Cor. 2.

Cor. 2. Ordo autem primæ differentiarum B, C, D, &c. quæ hoc modo evaneſcunt, idem eſt ac ordo differentiæ vel b, vel c, &c. unde incipit progreſſio illa Geometrica. Sic ſi $B = 0 = C =$ &c. erunt b, c, d, &c. in Progreſſione Geometrieâ ; ſi $C = 0 = D =$ &c. erunt c, d, &c. in Progreſſione Geometricâ. Et ſic porrò.

Lemma 6.] Iiſdem poſitis ſit r terminus unde incipit Progreſſio Geometrica in Serie differentiarum b, c, d, &c. & per $p+1$ deſignetur ordo Termini in Serie $\frac{\alpha}{b}$, $\frac{\beta}{b^2}$, $\frac{\gamma}{b^3}$, $\frac{\delta}{b^4}$, &c. Tum Terminus ille deſignabitur per fractionem cujus Denominatore exiſtente b^{p+1} Numerator eſt

$$\frac{a+bp+cp\times\frac{p-1}{2}+dp\times\frac{p-1}{2}\times\frac{p-2}{3}+\&c.+\frac{r}{q^n}}{\times b^p-1-qp-q^2p\times\frac{p-1}{2}-q^3p\times\frac{p-1}{2}\times\frac{p-2}{3}+\&c.}$$

nempe per n deſignato ordine differentiæ evaneſcentis in Serie B, C D, &c. ut & Numero terminorum $a+bp$, &c. item Terminorum $-1-qp$, &c.

Demonſtratio. Per *Lemma* 1. Termini iſtius Numerator exhibetur per formulam

$$a+bp+cp\,.\,\frac{p-1}{2}+dp\times\frac{p-1}{2}\,.\,\frac{p-2}{3}+\&c.\,(p+1 \text{ ſubeunte}$$

vices x in Lemmate iſto)

Ergò ſi ſit, *ex. gr.* $n=2$, per *Lemma* 5. *Cor.* 2. erunt c, d, &c. in ratione continuâ 1 ad q. Numerator itaque in hoc caſu eſt.

$$.\ a+bp+cp\times\frac{p-1}{2}+cqp\times\frac{p-1}{2}\times\frac{p-2}{3}+cq^2p\times\frac{p-1}{2}$$

$$\times\frac{p-2}{3}\times\frac{p-3}{4}+\&c.$$ Sed ſi termini $cp\times\frac{p-1}{2}+cqp\times\frac{p-1}{2}$

$$\times\frac{p-2}{3}+\&c.$$ ducantur in $\frac{q^2}{c}$, & productui addantur termini $1+qp$,

prodibit Series quâ exprimitur binomii $1+q$ dignitas $\overline{1+q}|^p = b^p$. Ergo productum illud æquale eſt b^p-1-qp; adeoque termini cp

$$\times\frac{p-1}{2}+cqp\times\frac{p-1}{2}\times\frac{p-2}{3}+\&c. = \frac{c}{q^2}\times\overline{b^p-1-qp},$$

Que

Quo pacto Numerator fit $a+bp+\frac{c}{q^2}\times\overline{b^p-1-qp}$, exiſtentibus duobus terminis $a+bp$, ut & duobus $-1-qp$, juxta ſenſum Propoſitionis, quoniam $n=2$. Atque eadem eſt Demonſtratio in aliis caſibus. De Denominatore verò per ſe ſatis conſtat.

Prop. IX. *Prob.*] Invenire ſummam quotlibet terminorum Seriei cujuſvis $\frac{M}{b}$, $\frac{N}{b^2}$, $\frac{O}{b^3}$, $\frac{P}{b^4}$, &c. cujus terminorum Denominatores conſtituunt Progreſſionem quamlibet Geometricam h, h^2, h^3, h^4, &c. Numeratores autem ſunt quantitates differentiâ aliquâ conſtanti gaudentes.

Solutio. Sunto Numeratorum M, N, O, P, &c. primus A, prima differentiarum primarum B, prima ſecundarum C, prima tertiarum D, & ſic porrò; & ſit ipſorum A, B, C, D, &c. numerus n, atque $b-1=q$, Tum fiat $a=A\ (=M)$, $b=bA+B$, $c=qbA+bB+C$, $d=q^2bA+qbB+bC+D$, &c. ut ſint tot termini a, b, c, d, &c. quot ſunt unitates in $n+1$. Terminorum iſtorum ultimus dicatur r, atque per $p+1$ deſignetur numerus terminorum $\frac{M}{b}$, $\frac{N}{b^2}$, $\frac{O}{b^3}$, $\frac{P}{b^4}$, &c. quorum ſumma requiritur; Dico ſummam illam exhiberi per fractionem, cujus Denominatore exiſtente b^{p+1}, Numerator eſt

$$\frac{a+bp+cp\times\frac{p-1}{2}+dp\times\frac{p-1}{2}\times\frac{p-2}{3}+\&c.+\frac{r}{q^n}}{\times b^p-1-qp-q^2p\times\frac{p-1}{2}-q^3p\times\frac{p-1}{2}\times\frac{p-2}{3}-\&c.}$$
$$\overline{-q^{n-1}p\times\frac{p-1}{2}\times\&c.}$$

Demonſtratio. Nam (per *Lem.* 6.) per hanc formulam repræſentatur terminus ordine $p+1$ Seriei $\frac{\alpha}{b}$, $\frac{\beta}{b^2}$, $\frac{\gamma}{b^3}$, $\frac{\delta}{b^4}$, &c. qui terminus (per conſtructionem *Lemmatis* 5.) æqualis eſt aggregato terminorum numero $r+1$ Seriei propoſitæ $\frac{M}{b}$, $\frac{N}{b^2}$, $\frac{O}{b^3}$, $\frac{P}{b^4}$. *Q. E. D.*

Ex. 1. Invenienda ſit ſumma novem terminorum Seriei $\frac{1}{2}$, $\frac{2}{4}$, $\frac{3}{1}$, $\overline{---}$

$\frac{4}{16}$, &c. Sunt in hoc casu $b=2$, $q\,(=b-1)=1$, $p+1=9$, $p=8$, $A=1, B=1, C=0, =D=$ &c. adeoque $n=2$, (quoniam sunt duo A, B,) Hinc fit $a(=A)=1$, $b\,(=bA+B=2\times1+1)=3$, $c\,(=qbA+bB+C=2\times1+2\times1+0)=4=r$, Adeoque per Formulam fit summa quæsita $\frac{1+3\times8+\frac{4}{1^2}\times\overline{2^8-1-1\times8}}{2^9}=\frac{1013}{512}$.

Ex. 2. Quæratur summa sex terminorum Seriei $1\times3+3\times3^2+6\times3^3+10\times3^4+15\times3^5+21\times3^6+$ &c. In hoc casu sunt $b=\frac{1}{3}$, $q=\frac{-2}{3}$, $p+1=6$, $p=5$, $A=1$, $B=2$, $C=1$, $D=0=E=$ &c. adeoque $n=3$, atque $a=1$, $b=\frac{1}{3}+2=\frac{7}{3}$, $c=\frac{-2}{9}+\frac{2}{3}+1=\frac{13}{9}$, $d=\frac{4}{27}-\frac{4}{9}+\frac{1}{3}=\frac{1}{27}=r$. Unde summa quæsita fit $=19956$ sive

$$\frac{1+\frac{7}{3}\times5+\frac{13}{9}\times5\times\frac{4}{2}+\frac{-1}{8}\times\frac{1}{3^5}\overline{-1+\frac{2}{3}\times5-\frac{4}{9}\times5\times\frac{4}{2}}}{\left|\frac{1}{3}\right|^6}$$

Corol. 1. Ejusdem Seriei, à termino primo $\frac{M}{b}$ in infinitum continuatæ, summa exhibetur per Formulam simpliciſſimam $\frac{A}{\overline{b-1}}+\frac{B}{\overline{b-1}|^2}+\frac{C}{\overline{b-1}|3}+\frac{D}{\overline{b-1}|4}$ &c.

Cor. 2. Si $b=2$, Seriei totius in infinitum continuatæ summa habetur solâ additione terminorum A, B, C, D, &c. Et hæc summa eadem est ac summa lineæ erectæ respondentis termino primo A, in Triangulo

Arithmetico, cujus Lineam tranſverſam occupant Numeratores *M*, *N*, *O*, *P*, *&c.* Quod facile conſtat ex Contemplatione Trianguli. Si itaque fuerint *M*, *N*, *O*, *&c.* Numeri figurati cujuſvis Ordinis *n*, ſumma Seriei $\frac{M}{2} + \frac{N}{4} + \frac{O}{8} + \frac{P}{16} + \&c.$ æqualis erit Numeri binarii dignitati $\overline{2}|^{n-1}$. Sic Series $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \&c. = 2^{1-1} = 1$, ut vulgò notum; Series $\frac{1}{2} + \frac{2}{4} + \frac{3}{8} + \frac{4}{16} + \&c. = 2^{2-1} = 2$; Series $\frac{1}{2} + \frac{3}{4} + \frac{6}{8}\,\frac{10}{16} + \&c. = 2^{3-1} = 2^2 = 4$, & ſic porrò.

Scholium. Celeb. D. *Jac. Bernoulli*, in tractatu ſuo de Seriebus infinitis, ſolvit illud Problema. ‘ Invenire ſummam Seriei infinitæ Fractionum quarum Denominatores creſcunt in Progreſſione quacunque Geometricâ, Numeratores verò progrediuntur vel juxta Numeros naturales, 1, 2, 3, 4, *&c.* vel Trigonales 1, 3, 6, 10, *&c.* vel Pyramidales 1, 4, 10, 20, *&c.* aut juxta Quadratos 1, 4, 9, 16, *&c.* aut Cubos 1, 8, 27, 64, *&c.* eorumve multiplices.’ Ipſius Solutionem conſulat Lector. Aliam verò, & quidem multo generaliorem invenit D. *Nic. Bernoulli* illius Nepos, eamque poſtquam ei hæc miſeram, ſed ſine Demonſtratione) mecum communicare dignatus eſt, in Epiſtolâ datâ 18° *Septembris* 1715, miris quidem inventis refertiſſimâ, qualibus me crebro dignatur vir doctiſſimus. De hoc vero Problemata ſic ſcribit. ‘ Pour la ſomme d’un nombre determiné *n* de termes de la ſuite de vôtre Theoreme 7. [*Corollarium* primum eſt hujus Propoſitionis] j’ay

‘ trouvé cette Formule $\frac{1}{m^n} \times$

$$\times \frac{m-1}{m-1}a + \frac{A-n}{m-1}b + \frac{B-n\cdot\frac{n-1}{2}}{m-1}c + \frac{C-n\cdot\frac{n-1}{2}\cdot\frac{n-2}{3}}{m-1}d + \&c.$$

‘ ou les Lettres *A*, *B*, *C*, *&c.* marquent les Coefficientes des termes immediatement precedents. Et en mettant dans cette Formule $p + 1$ pour *n*, b^m pour *m*, & en multipliant tout encore par e^{m-1}, on a la Solution de vôtre *Prob.* IX^m e’ Et me monuit Vir peritiſſimus hanc

ſuam formulam generalem in noſtram particularem (*Cor.* 1. hujus propoſitionis) migrare quando $n = \infty$; quippe tum evaneſcunt 1, n, $n.\frac{n-1}{2}$, $n.\frac{n-1}{2}.\frac{n-2}{3}$, &c. reſpectu ipſorum m^n, A, B, C, &c.

adeo ut Series in eo caſu ſit $\frac{1}{m-1}a + \frac{A}{m-1}b + \frac{B}{m-1}c + \&c.$

quæ omnino coincidit cum noſtrâ $\frac{a}{m-1} + \frac{b}{\overline{m-1}^2} + \frac{c}{\overline{m-1}^3} + \&c.$

Adhuc aliam hujus Problematis ſolutionem, & quidem ab hiſce admodum diverſam, invenit D. *Taylor* ope Methodi ſuæ Incrementorum. Viri doctiſſimi rogatu, ad eum miſeram formulam meam ſecundam pro ſolutione Problematis II^di, item formulas alias ſpectantes ad Propoſitiones tertiam, quartam & quintam, ſed ſine demonſtrationibus: quippe non dubitabam quin Vir acutiſſimus, atque ipſe Methodi iſtius Incrementorum Inventor, hiſce, vel ſaltem paribus inveniendis par eſſet. Reſcripſit ſe harum ſolutiones inveniſſe, & ſimul alia quædam communicavit ad hujus methodi profectum multum facientia, quæ jam noſtro hortatu inductus hiſce ſubjungere dignatur.

APPENDIX *Quâ methodo diversâ eadem materia tractatur.*

An Appendix by Dr. B. Taylor, *ibid.* p. 676.

Hortatu Viri Clariſſ. ſequentes jam Propoſitiones exhibemus, quas quidem in aliam occaſionem reſervandas eſſe decreviſſemus, ni æquum viſum fuiſſet parendum eſſe imperio amici qui, dum Propoſitiones quaſdam præcedentes ſuas olim nobis inveſtigandas propoſuit, earum inveniendarum occaſionem dedit.

Definitiones.] 1. Quantitatis cujuſvis variabilis valorem præſentem deſigno literâ ſimpliciter ſcriptâ, ut x; valores præcedentes diſtinguo lineolis eidem literæ ex parte ſuperiori poſitis, ſequentes lineolis ex parte inferiori ſcriptis. Ut vi hujus Definitionis ſint $\overset{\prime\prime}{x}$, $\overset{\prime}{x}$, x, $\underset{\prime}{x}$, $\underset{\prime\prime}{x}$, ejuſdem variabilis valores quinque continui, exiſtente x valore præſenti, $\overset{\prime}{x}$ proximè præterito, $\overset{\prime\prime}{x}$ ſecundò præterito; $\underset{\prime}{x}$ proximè, atque $\underset{\prime\prime}{x}$ ſecundò futuro. Et ſic de aliis. Ad eundem modum ſunt interpretandæ lineolæ quæ incrementis apponuntur. Sic ſunt $\overset{\prime\prime}{\dot{x}}$, $\overset{\prime}{\dot{x}}$, $\dot{x}$, $\underset{\prime}{\dot{x}}$, $\underset{\prime\prime}{\dot{x}}$, ipſius $\dot{x}$ valores

quin-

quinque continui; ut ſit $\ddot{x}$ incrementum ſecundum ipſius $\ddot{x}$, ſit $\dot{x}$ incrementum ſecundum ipſius $\dot{x}$. Et ſic de aliis.

Cor. Vi hujus Definitionis, $\dot{x} + \dot{x} = x$, $x + \dot{x} = \dot{x}$, $\dot{x} + \ddot{x} = \ddot{x}$. Et ſic de aliis hujuſmodi.

Quando uſu venit ut variabilis quantitas, puta x, ſpectanda ſit tanquam Incrementum, ejus Integrale deſigno literâ inter uncos [ ] incluſa. Iſtius etiam Integralis $[x]$ Integrale (vel ipſius x Integrale ſecundum,) deſigno numero binario uncorum priori ſuperimpoſito, ut $\overset{2}{[}x]$. Iſtius etiam Integralis Integrale (vel ipſius x Integrale tertium,) ad eundem modum deſigno numero ternario, ut $\overset{3}{[}x]$. Et ſic deinceps. Unde vi hujus Definitionis conſtituunt $\overset{3}{[}x]$, $\overset{2}{[}x]$, $[x]$, x Seriem terminorum, quorum quilibet eſt ipſum immediatè præcedentis incrementum primum, ut ſit $\overset{2}{[}x] = \overset{3}{[}\dot{x}]$, $[x] = \overset{2}{[}\dot{x}]$, $x = [\dot{x}]$.

Lemma.] Facti xv ex Multiplicatione duorum variabilium x & v, incrementum eſt $\dot{x}v + x\dot{v}$.

Nam auctis variabilibus per propria incrementa, fit novum productum $\overline{x + \dot{x}} \times \overline{v + \dot{v}}$, ſive $xv + \dot{x}v + \overline{x + \dot{x}} \times \dot{v}$, hoc eſt $xv + \dot{x}v + x\dot{v}$ (pro $x + \dot{x}$ ſcripto $\dot{x}$ *per Def.* 1.) Unde dempto priori producto xv, reſtat Incrementum $\dot{x}v + x\dot{v}$.

Prop. I. *Theor.*] Ejuſdem Facti xv Incrementum, vel primum, vel ſecundum, vel tertium, vel aliud quodvis, cujus ordo deſignatur per ſymbolum n, exhibetur per formulam hanc generalem

$$\dot{x}v + n\dot{x}\dot{v} + n \times \frac{n-1}{2}\ddot{x}\dot{v} + n \times \frac{n-1}{2} \times \frac{n-2}{3}\dddot{x}\dot{v} + \&c.$$

In hâc Formulâ hæc ſunt obſervanda, 1^mo^ Terminorum Coefficientes $1, n, n \times \frac{n-1}{2}, n \times \frac{n-1}{2} \times \frac{n-2}{3}$ &c. iidem ſunt ac in bi-

nomii dignitate n. 2do Numeri n, $n-1$, $n-2$, $n-3$, &c. ipſis x infraſcripti deſignant numeros punctorum quibus definiuntur Incrementa. 3^{tio} Lineolæ $_{,}$, $_{,,}$, $_{,,,}$, &c. ipſis x infraſcriptæ, interpretandæ ſunt per Def. 1. 4to. In quovis Termino numerus punctorum ipſis x & v ſimul infraſcriptorum, eſt n. Sit *v. g.* $n=4$: tum per Formulam, ipſius xv incrementum quartum prodit $\overset{::}{x}v+4\overset{\cdot:}{x}\overset{\cdot}{v}+6\overset{-:}{x}\overset{-}{v}+4\overset{\cdot\cdot:}{x}\overset{\cdot\cdot}{v}+\overset{::}{x}v$.

Theorema hoc generale demonſtrari poteſt per Inductionem, incrementis continuò ſumptis juxta formam in Lemmate præcedenti traditam. Sed & collectâ formâ Seriei ex hujuſmodi calculo, Theorema etiam demonſtrari poteſt per Methodum Incrementorum, ad eum modum cujus Specimen mox dabimus in Demonſtratione Propoſitionis tertiæ.

Prop. 2. *Theor.*] Ipſius xv Integrale primum $[xv]$ exhibetur per Seriem $[x]v-\overset{2}{[}\overset{\cdot}{x}]\overset{\cdot}{v}+\overset{3}{[}\overset{\cdot\cdot}{x}]\overset{\cdot\cdot}{v}-\overset{4}{[}\overset{\cdot\cdot\cdot}{x}]\overset{\cdot\cdot\cdot}{v}$ &c.

Series autem ita terminatur, ut ſit $[xv]=[x]v-\left[\overset{\cdot}{[}\overset{\cdot}{x}]\overset{\cdot}{v}\right]=[x]v-\overset{2}{[}\overset{\cdot}{x}]\overset{\cdot}{v}+\left[\overset{2}{[}\overset{\cdot\cdot}{x}]\overset{\cdot\cdot}{v}\right]=$ &c.

Nam ſumendo incrementa reſtituitur propoſitum xv.

Cor. 1. Datis duobus ex iſtis $[x]$, $[xv]$, $\left[\overset{\cdot}{[}\overset{\cdot}{x}]\overset{\cdot}{v}\right]$, datur tertium.

Item datis tribus ex iſtis $[x]$, $\overset{2}{[}\overset{\cdot}{x}]$, $[xv]$, $\left[\overset{2}{[}\overset{\cdot\cdot}{x}]\overset{\cdot}{v}\right]$, datur quartum, Et ſic porrò

Cor. 2. Si $\overset{\cdot}{v}=0$, datur $[xv]$ ex dato $[x]$. Si $\overset{\cdot\cdot}{v}=0$ datur $[xv]$, ex datis duobus $[x]$, & $\overset{2}{[}x]$, Si $\overset{\cdot\cdot\cdot}{v}=0$, datur $[xv]$, ex datis tribus $[x]$, $\overset{2}{[}x]$, $\overset{3}{[}x]$. Et ſic porrò.

Ex. 1. Sit exemplum hujus Formulæ in Inventione Integralis ipſius $\frac{v}{zzzz}$, dato nempe z, atque exiſtente $\overset{\cdot\cdot}{v}=0$, qui caſus eſt ſpecialis Propoſitionis ſecundæ Tractatus præcedentis D^{ni} *Monmort*. Facto itaque $x=\frac{1}{zzzz}$, ſunt $[x=]\frac{-1}{3zzzz}$, $\overset{2}{[}\overset{\cdot}{x}]=\frac{1}{2z\times 3zzz}$, atque

$\overset{3}{[}\overset{\prime\prime}{x}] = \frac{=1}{1z \times 2z \times 3zz}$. Unde per Formulam fit $[xv]$, hoc eſt

$$\left[\frac{v}{z\,z\,z\,z}\right] = -\frac{v}{3zzzz} - \frac{\dot{v}}{2z \times 3zzz} - \frac{\ddot{v}}{1z \times 2z \times 3zz}.$$

Ex. 2. Sit aliud exemplum in Inventione Integralis ipſius $n a^z$, ubi eſt $z = 1$, atque datur a, Tum pro x ſumpto a^z, & pro v ſumpto n, fit $x = \overset{z}{a}$ hoc eſt $\dot{x} = ax$, ſeu $x + \dot{x} = ax$, adeoque $\dot{x} = \overline{a-1}\,x$, atque $x = \frac{\dot{x}}{a-1}$. Regrediendo itaque ad integralia fit $[x] = \frac{x}{a-1}$; item $\overset{2}{[}x] = \frac{[x]}{a-1} = \frac{x}{\overline{a-1}|^2}$, item $\overset{3}{[}x] = \frac{x}{\overline{a-1}|^3}$; & ſic porrò. Adeoque (quoniam $\dot{x} = ax$,) ſunt $[x] = \frac{\dot{x}}{a-1}$, $[\dot{x}] = \frac{a\dot{x}}{\overline{a-1}|^2}$, $[\overset{\prime\prime}{x}] = \frac{a^2 x}{\overline{a-1}|^3}$, &c. Unde per Formulam prodit $[n a^z] = \frac{a^z n}{a-1} - \frac{a^{z+1} n}{\overline{a-1}|^2} + \frac{a^{z+2} n}{\overline{a-1}|^3}$ &c.

In hoc exemplo continetur Solutio Problematis, de quo agit Dnus de *Monmort* in Propoſitione nona. Coincidit autem Formula cum ea quam exhibet ille in Corollario primo ejuſdem Propoſitionis.

Scholium. Poſſunt etiam ex hâc Formula alii derivati valores Integralis quæſiti, pro vario modo quo interpretantur Incrementi propoſiti Factores. Sic in exemplo ſecundo integrale ipſius $n a^z$ exhibere poteſt per Formulam $a^z [n] - \overline{a-1}\, a^z \overset{2}{[}\dot{n}] + \overline{a-1}|^2\, a^z \overset{3}{[}\overset{\prime\prime}{n}] +$ &c. pro x nempe ſumpto n, & pro v ſumpto a^z. Sed de his fortaſſe aliâ occaſione fuſius dicemus.

Prop. III. *Theor.*] Ejuſdem xv Integrale, vel primum, vel ſecundum, vel tertium, vel aliud quodvis cujus ordo deſignatur ſymbolo n, exhibetur per Seriem in hâc formâ generali prodeuntem $\overset{n}{[}xv] = \overset{n}{[}x]$

$v -$

$$v - n\overset{n+1}{[}\overset{}{x}\overset{}{,}]\,\dot{v} + n \times \frac{n+1}{2}\,\overset{n+2}{[}\overset{}{x}\overset{}{''}]\,\ddot{v} - n \times \frac{n+1}{2} \times \frac{n+2}{3}\,\overset{n+3}{[}\overset{}{x}\overset{}{'''}]\,\dddot{v} + \&c.$$

Collectâ formâ Seriei ex Propoſitione præcedenti, Coefficientes 1, $-n$, $n \times \frac{n+1}{2}$, $-n \times \frac{n+1}{2} \times \frac{n+2}{3}$, &c. ſic inveniuntur per Methodum Incrementorum. Pone $\overset{n}{[}x\,v] = A\overset{n}{[}x] v + B\overset{n+1}{[}\overset{}{x}\overset{}{,}]\,\dot{v} + C\overset{n+2}{[}\overset{}{x}\overset{}{''}]\,\ddot{v} + D\overset{n+3}{[}\overset{}{x}\overset{}{'''}]\,\dddot{v} + \&c.$ Tum aucto n incremento ſuo $\dot{n} = 1$, atque ipſis A, B, C, D, &c. incrementis ſuis contemporaneis $\dot{A}$, $\dot{B}$, $\dot{C}$, $\dot{D}$, &c. ut jam evadant n, A, B, C, D, &c. fiet novum Integrale (quod Integrale eſt ipſius $\overset{n}{[}x\,v]$,) $\overset{n+1}{[}x\,v] = A\overset{n+1}{[}x] v + B\overset{n+2}{[}\overset{}{x}\overset{}{,}]\,\dot{v} + C\overset{n+3}{[}\overset{}{x}\overset{}{''}]\,\ddot{v} + D\overset{n+4}{[}\overset{}{x}\overset{}{'''}]\,\dddot{v} + \&c.$ Hujus itaque Incrementum primum coincidere debet cum Integrali prius poſito. Sumptis ergo incrementis, fit $\overset{n}{[}x\,v] =$

$$A\overset{n}{[}x]\,\dot{v} + A\overset{n+1}{[}\overset{}{x}\overset{}{,}]\,\ddot{v} + B\overset{n+2}{[}\overset{}{x}\overset{}{''}]\,\dddot{v} + C\overset{n+3}{[}\overset{}{x}\overset{}{'''}]\,\ddddot{v} +$$
$$+ B + C + D$$

idem ac Integrale prius poſitum. Itaque terminos homologos inter ſe comparando fit 1mo $A = A$. Unde eſt A datum quid. Sed ubi $n = 0$, eſt $A = 1$, ergo $A = 1$. 2do. $B = B + A$, hoc eſt $B = B + B + 1$, ſeu $B = -1 = -n$. Ergo regrediendo ad Integralia, fit $B = -n + a$. Sed ubi $n = 0$, eſt $B = 0$. Ergo $a = 0$, atque $B = -n$. 3tio. $C = C + B$, hoc eſt $C = n$. Regrediendo itaque ad Integralia fit $C = \frac{nn}{2} + b$. Sed ubi $n = 0$, eſt $C = 0$. Ergo $b = 0$, atque $C = \frac{nn}{2}$, hoc eſt, $n \times \frac{n+1}{2}$. 4to. Ad eundem modum invenitur $D =$

$D = -n \times \frac{n+1}{2} \times \frac{n+2}{3}$. Et ſic pergendo inveniuntur cæteri Coefficientes.

Scholium. 1. In hâc Propoſitione comparatâ cum Propoſitione primâ, cernitur ſingularis quædam relatio Incrementa inter & Integralia. Ut enim in Arithmeticâ vulgari, Multiplicatio & Diviſio ſunt invicem ita contrariæ ut ſi Multiplicatio deſignetur per Indicem affirmativum, Diviſio deſignabitur per Indicem cum ſigno negativo; ſic etiam in Methodo Incrementorum, ſi Incrementum deſignetur per Indicem affirmativum, Index negativus Integrale ſiſtet. Sic in Propoſitione primâ, ſi pro n ſumatur Numerus binarius 2, per formulam exhibebitur ipſius $x\,v$ incrementum ſecundum, nempe $\dot{x}\,\dot{v} + 2\,\dot{x}\,v + x\,v$; Sed ſi pro n ſumatur numerus negativus -2, ut jam quæratur ipſius $x\,v$ incrementum (ita loqui liceat) negativè ſecundum, (quod idem eſt ac Integrale ſecundum) prodeunt Coefficientes iidem ac ſi ſumatur n affirmativè in Propoſitione præſenti: utque interpretatis inſuper ipſis x, $\dot{x}$, $\ddot{x}$, &c. per $[x]^2$, $[\dot{x}]^3$, $[\ddot{x}]^4$, &c. Series fit omnino eadem ac per Propoſitionem præſentem prodit, ubi quæritur Integrale ſecundum.

2. Ex his autem formulis quaſi ſuâ ſponte procedunt formulæ Propoſitionum undecimæ atque duodecimæ Libri de Methodo Incrementorum. Nam pro incrementis ſcribe Fluxiones, atque evaneſcentibus incrementis fiant jam omnes x, $\dot{x}$, $\ddot{x}$, $\dddot{x}$, &c. inter ſe æquales, atque migrabit ſtatim hæc Propoſitio ſecunda in illam undecimam, atque præſens tertia in illam duodecimam. Quod quidem exemplum ſatis inſigne eſt Methodi *Newtonianæ*, quâ colligit ille rationes Fluxionum ex rationibus ultimis Incrementorum evaneſcentium, vel ex primis naſcentium.

Additamentum.] Præcedentium impreſſioni intentus dum Typothetarum erroribus corrigendis do operam, atque eâ occaſione in animo illa ſæpius revolvo, ſubiit Artificium illud quo jam olim uſus eſt D. *Jac. Bernouilli* in inventione quarundam Serierum, ope Progreſſionis Harmonicæ, cujus meminit D. de *Monmort* in *Scholio* 6. *Prop.* V. præcedente commodè etiam applicari poſſe ad inventionem ipſius *Monmortii* Propoſitionum 2^{da}, 3^{tia}, 4^{ta}, 5^{ta}, atque id genus aliarum aliquanto fortaſſe generaliorum. Hoc in ſequentibus paucis oſtendiſſe, credebam Lectori non fore ingratum.

A Poſtſcript *by the ſame,* ibid. p. 683.

Theorema.] Sit Progreſſio Arithmetica p, $p + n$, $p + 2n$, &c. cujus termini ſinguli ſucceſſivè deſignentur per x, & ſunto b, c, d, &c. quivis multiplices differentiæ datæ n terminorum Progreſſionis iſtius Arithmeticæ. Sint A, B, C, D, &c. Numeri quilibet dati, & conſtituantur

Fractiones quotvis $\frac{A}{x}$, $\frac{B}{x+b}$, $\frac{C}{x+c}$, $\frac{D}{x+d}$, &c. Pro x ſucceſſivè ſcriptis valoribus ſuis p, $p+n$, $p+2n$, &c. ex harum Fractionum quâlibet, oritur Series harmonicè proportionalium. Sic *v. g.* ex Fractione primâ $\frac{A}{p}$, oritur Series $\frac{A}{p}$, $\frac{A}{p+n}$, $\frac{A}{p+2n}$, &c. Dico quod aggregatum quotlibet hujuſmodi Serierum in infinitum continuatarum in terminis numero finitis exhiberi poteſt, ſi modo fuerit Numeratorum A, B, C, D, &c. aggregatum æquale nihilo. Duobus exemplis hoc fiet manifeſtum.

Ex. Sint duæ tantùm Fractiones $\frac{A}{x}$, atque $\frac{-A}{x+3n}$, exiſtente $b=3n$.

Scribantur Series harmonicæ ex his Formulis ortæ, eo Ordine, ut termini, in quibus ſunt Denominatores æquales, ſibi invicem reſpondeant, & collectis ſummis terminorum Homologorum, prodibit aggregatum Serierum in terminis numero finitis, ut in calculo appoſito videre eſt.

$$\frac{A}{p}+\frac{A}{p+n}+\frac{A}{p+2n}+\frac{A}{p+3n}+\frac{A}{p+4n}+\&c. = \text{Seriei ortæ ex } \frac{A}{x}$$

$$+\frac{-A}{p+3n}+\frac{-A}{p+4n}+\&c. = \text{Seriei ex } \frac{-A}{x+3n}$$

$$\frac{A}{p}+\frac{A}{p+n}+\frac{A}{p+2n}+0+0+\&c. = \text{Aggreg. Serierum.}$$

Ex. 2. Sint tres Fractiones $\frac{A}{x}$ $\frac{B}{x+2n}$, $\frac{C}{x+3a}$, exiſtentibus $b=2n$, $c=3n$, atque $A+B+C=0$. In hoc caſu Calculus ſic ſe habet.

$$\frac{A}{p}+\frac{A}{p+n}+\frac{A}{p+2n}+\frac{A}{p+3n}+\ldots+\&c. = \text{Seriei ortæ ex } \frac{A}{x}$$

$$+\frac{B}{p+2n}+\frac{B}{p+3n}+\ldots.+\&c. = \text{Seriei ex } \frac{B}{x+2n}$$

$$+\frac{C}{p+3n}+\ldots..+\&c. = \text{Seriei ex } \frac{C}{x+3n}$$

$$\frac{A}{p}+\frac{A}{p+n}\ \frac{A+B}{p+2n}+\frac{A+B+C=0}{p+3n}+\&c. = \text{Aggregato Serierum.}$$

Ubi

Ubi etiam prodit aggregatum Serierum in terminis numero finitis, nempe $\frac{A}{p} + \frac{A}{p+n} + \frac{A+n}{p+2n}$, ob Numeratorum A, B, C, aggregatum æquale nihilo. Et ad eundem modum demonſtratur Theorema in aliis caſibus quibuſvis.

Cor. 1. Ex his principiis derivari poſſunt innumeræ Series in infinitum continuatæ, in terminis tamen numero finitis ſummabiles.

Caſ. 2. Sint $\frac{1}{x}$ & $\frac{A-A}{x+b}$ Formulæ duarum Serierum harmonicarum quarum aggregatum prodit in terminis numero finitis per ſuperius demonſtrata. Tum Formulis iſtis in unam ſummam collectis, fit $\frac{Ab}{x \times \overline{x+b}}$ Formula Seriei ſummabilis. Sint *v. gr.* $A = \frac{1}{6}$, $p = 1$, $n = 2$, atque $b = 3\ n = 6$. Tum Formulæ Serierum harmonicarum erunt $\frac{1}{6x}$, & $\frac{1}{6 \times \overline{x+6}}$, Formula Seriei compoſitæ ſummabilis erit $\frac{1}{x \times \overline{x+6}}$, Serie illa exiſtente $\frac{1}{1 \times 7} + \frac{1}{3 \times 9} + \frac{1}{5 \times 11} + \frac{1}{7 \times 13}$ &c. atque ſumma Seriei, per calculum in præmiſſis demonſtratum, erit $\frac{1}{6 \times 1} + \frac{1}{6 \times 3} + \frac{1}{6 \times 5}$.

Sint tres Formulæ Serierum harmonicarum $\frac{A}{x}$, $\frac{A}{x+b}$, $\frac{C}{x+c}$, exiſtente $A + B + C = 0$, ut ſit Serierum aggregatum finitum per præmiſſa. Tum Formulis in unam ſummam collectis fit

$$\frac{A \times \overline{x+b} \times \overline{x+c} + B \times x \times \overline{x+c} + C \times x \times \overline{x+b}}{x \times \overline{x+b} \times \overline{x+c}},$$

ſeu (terminis revocatis ad Formam Factorum x, $x \times \overline{x+b}$, $x \times \overline{x+b} \times \overline{x+c}$,)

$$\frac{Acb + \overline{Ac + c - b}\, B \times x + \overline{A + B + C} \times x \times \overline{x+b}}{x \times \overline{x+b} \times \overline{x+c}},$$

hoc eſt (ob

$A+B+C=0)\ \frac{Acb+\overline{Ac+B\times c-b}\times x}{xxx+b\times\overline{x+c}}$, Formula Seriei ſumma-

bilis. Si quatuor ſint Fractiones $\frac{A}{x}$, $\frac{B}{x+b}$, $\frac{C}{x+c}$, $\frac{D}{x+d}$, exiſtente

$A+B+C+D=0)$ ad eundem modum invenietur Formula Seriei ſummabilis

$$\frac{\overline{Abcd+\overline{Acd+B\times\overline{c-b}\times\overline{d-b}}}\times xx+\overline{\overline{Ad+B\times\overline{d-b}+C\times\overline{d-c}}\times xx\times\overline{x+b}}}{xx\times\overline{x+b}\times\overline{x+c}\times\overline{x+d}}$$

Et ſic pergere licet ad Formulas adhuc magis compoſitas.

Caſ. 2. Et ſi plures ſint Formulæ Serierum hujuſmodi ſummabilium, quarum Denominatorum Factores excerpantur ex diverſis Progreſſionibus Arithmeticis, ex iſtarum Formularum quotvis in unam ſummam additione, conficietur Formula nova Seriei ſummabilis. Sint *e. gr.* Formulæ

duæ Serierum ſummabilium $\frac{1}{x\times\overline{x+3}}$ & $\frac{1}{z\times\overline{z+2}}$, excerptis x ex Pro-

greſſione Arithmeticâ 1, 2, 3, 4, *&c.* z ex Progreſſione Arithmeticâ 1, 3, 5, *&c.* Tum ex his Formulis in unam ſummam collectis fiet For-

mula nova $\frac{z\times\overline{z+2}+x\times\overline{x+3}}{x\times\overline{x+3}\times z\times\overline{z+2}}$, vel, (expoſito z per x & numeros

datos.) $\frac{\overline{2x-1}\times\overline{2x+1}+x\times\overline{x+3}}{x\times\overline{x+3}\times\overline{2x-1}\times\overline{2x+1}}$

Cor. 2. Hinc omnis Series in infinitum continuata ſummabilis eſt, cujus termini deſignantur per Fractionem, cujus Denominatoris Factores excerpuntur ex datâ quâlibet Progreſſione Arithmeticâ, Numerator autem eſt multinomium, cujus Dimenſiones ſunt ad minimum binario pauciores, quam ſunt Dimenſiones Denominatoris. Nam omnis hujuſmodi Fractio reſolvi poteſt in tot Fractiones ſimplices, quot ſunt Dimenſiones (hoc eſt, quot ſunt Factores) Denominatoris, quarum Numeratorum aggregatum eſt nihil. Sit exempli gratiâ, Formula oblata

$\frac{\alpha+\beta x+\gamma x\times\overline{x+b}}{x\times\overline{x+b}\times\overline{x+c}\times\overline{x+d}}$. Pone hanc Formulam æquari aggregato

Fractionum $\frac{A}{x}+\frac{B}{x+b}+\frac{C}{x+c}+\frac{D}{x+d}$. Tum Fractionibus iſtis in unam

unam ſummam collectis fiet $Abcd+\overline{Acd+B\overline{c-b}\times\overline{d-b}\times x}$

$+\overline{Ad+B\times\overline{d-b}+C\times\overline{\overline{d-c}\times x}\times x\times\overline{x+b}}$

$+\overline{A+B+C+D\times x\times x\times\overline{x+b}\times\overline{x+c}}$ applicatum ad $x\times\overline{x+b}$

$\times x\overline{+c}\times\overline{x+d}=\dfrac{\alpha+\beta x+\gamma x\times\overline{x+b}}{x\times\overline{x+b}\times\overline{x+c}\times\overline{x+d}}$.

Unde per comparationem terminorum homologorum fit $Abcd=\alpha$, $Acd+B\times\overline{c-b}\times\overline{d-b}=\beta$, $Ad+B\times\overline{d-b}+C\times\overline{d-c}$ $=\gamma$, $A+B+C+D=0$, adeoque $A=\dfrac{\alpha}{bcd}$, $B=\dfrac{\beta-Acd}{\overline{c-b}\times\overline{d-b}}$, $C=\dfrac{\gamma-Ad-B\times\overline{d-b}}{d-c}$, $D=-A-B-C$, Quo pacto Formula oblata reſolvitur in Fractiones ſimplices $\dfrac{\alpha}{bcdx}$

$+\dfrac{\beta-Acd}{\overline{c-b}\times\overline{d-b}\times\overline{x+b}}+\dfrac{\gamma-Ad-B\times\overline{d-b}}{\overline{d-c}\times\overline{x+c}}$

$+\dfrac{-A-B-C}{x+d}$, ex quibus ortarum Serierum aggregatum, hoc eſt, ſumma Seriei ortæ ex Formulâ oblatâ $\dfrac{\alpha+\beta x+\gamma x\times\overline{x+b}}{x\times x+b\times\overline{x+c}\times\overline{x+d}}$, per jam dicta prodit in terminis numero finitis. Quod verò Dimenſiones Numeratoris in Formulâ oblatâ, debeant eſſe binario ad minimum pauciores, quam ſunt Dimenſiones Denominatoris, hinc conſtat, quòd in reductione Fractionum $\dfrac{A}{x}$, $\dfrac{B}{x+b}$, $\dfrac{C}{x+c}$, $\dfrac{D}{x+d}$, quilibet Numerator A, B, C, D, ducitur in omnes Denominatores excepto uno, nempe ſuo; unde prodeunt Numeratoris Dimenſiones Unitate pauciores quam ſunt Dimenſiones Denominatoris. Sed per Æquationem $A+B+C+D=0$ perit altiſſima Dimenſio in Numeratore; Unde ſuperſunt Numeratoris Dimenſiones ad minimum binario pauciores quam ſunt Dimenſiones Denominatoris. Ad hoc verò Corollarium revocari poſſunt de *Monmort* Propoſitiones 2^da^ & 5^ta^.

Cor. 3. Item oblatâ Formulâ juxta *Caſ.* 2. *Cor.* 1. adhuc magis compoſitâ, ex iiſdem principiis perſpici poteſt an ſit Series ſummabilis. Sint Progreſſiones duæ Arithmeticæ 1, 3, 5, &c. 2, 4, 6, &c. quarum termini Homologi deſignentur per x & z, & ſit Formula Seriei oblata $\frac{\alpha + \beta x + \gamma x^2}{x \times \overline{x+2} \times z \times \overline{z+2}}$, vel pro z ſcripto $x+1$, & Factoribus Denominatoris in Ordinem coactis) $\frac{\alpha + \beta x + \gamma x^2}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}}$.

Pone Formulam hanc æquari aggregato Formularum $\frac{P}{x \times \overline{x+2}}$, $\frac{Q}{\overline{x+1} \times \overline{x+3}}$, Serierum per ſuperius dicta ſummabilium, ut (Formulis his noviſſimis in unam ſummam collectis) ſit

$$\frac{P \times \overline{x+1} \times \overline{x+3} + Q \times x \times \overline{x+2}}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}} \text{ ſeu } \frac{3P + 4\overline{P+2}Q x + \overline{P+Q} x^2}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}} = \frac{\alpha + \beta x + \gamma x^2}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}}.$$

Hinc comparando terminos homologos oriuntur Æquationes $3P = \alpha$, $4P + 2Q = \beta$, $P + Q = \gamma$. Unde eliminatis P & Q per debitas Operationes analyticas, prodit Æquatio $2\alpha - 3\beta + \gamma = 0$, qua definitur Relatio quæ inter Coefficientes α, β, γ, intercedere debet, ut Series orta ex Formula oblatâ $\frac{\alpha + \beta x + x^2}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}}$ ſit ſummabilis. Ad eundem modum ſi Formulæ oblatæ Denominatoris Factores excerpantur ex tribus Progreſſionibus Arithmeticis invenientur duæ Æquationes quibus definiantur Relationes Coefficientium Numeratoris ut ſit Series ſummabilis. Si quatuor ſint Progreſſiones Arithmeticæ, Coefficientium Relatio definietur per tres Æquationes. Et ſic porrò. Et in hujuſmodi Formulis ut ſint Series ſummabiles, hæc inſuper obſervanda ſunt, Primò ut Numeratorum Dimenſiones ſint ad minimum binario pauciores quam ſunt Dimenſiones Denominatorum, deinde ut ex ſingulis Progreſſionibus Arithmeticis excerpantur ad minimum duo Factores Denominatoris. Denique, quod ſi ſint duo vel plures Factores Denominatoris inter ſe æquales, ponendum ſit tot etiam Progreſſiones arithmeticas, ex quibus excerpuntur, eſſe inter ſe æquales. Præmiſſis

attentius perpenſis, hæc obvia erunt. Ad hoc vero Corollarium facile revocantur D. de *Monmort* Propoſitiones 3^tia & 4^ta.

XIX. Propoſitio.] *Invenire Lineam Parabolicam quæ tranſibit per extrema Ordinatorum quotcunque Æquidiſtantium.*

The Newtonian *Differential Method explain'd, by Mr.* J. Stirling. n. 362. p. 1050.

$A\ A2\ A3\ A4\ A5\ A6\ A7\ A8\ A9$
$B\ B2\ B3\ B4\ B5\ B6\ B7\ B8$
$C\ C2\ C3\ C4\ C5\ C6\ C7$
$D\ D2\ D3\ D4\ D5\ D6$
$E\ E2\ E3\ E4\ E5$
$F\ F2\ F3\ F4$
$G\ G2\ G3$
$H\ H2$
I

Fig. 33.

Caſus 1.] Deſignent A, $A2$, $A3$, $A4$, $A5$, $A6$, $A7$, $A8$, $A9$, &c. Ordinatas æquidiſtantes inſiſtentes Abſciſſæ in dato Angulo. Collige earum Differentias B, $B2$, $B3$, $B4$, $B5$, $B6$, $B7$, $B8$, &c. harumque Differentias C, $C2$, $C3$, $C4$, $C5$, $C6$, $C7$, &c. harumque Differentias D, $D2$, $D3$, $D4$, $D5$, $D6$, &c. harumque Differentias E, $E2$, $E3$, $E4$, $E5$, &c. harumque F, $F2$, $F3$, $F4$, &c. Et ſic porrò. Differentiæ autem colligi debent auferendo priores ſemper de poſterioribus. Hoc eſt ponendo $B = A2 - A$, $B2 = A3 - A2$, $B3 = A4 - A3$, $B4 = A5 - A4$, $B5 = A6 - A5$, &c. Tum $C = B2 - B$, $C2 = B3 - B2$, $C3 = B4 - B3$, $C4 = B5 - B4$, &c. deinde $D = C2 - C$, $D2 = C3 - C2$, $D3 = C4 - C3$, &c. Et ſimiliter ſunt omnes Differentiæ ſequentes colligendæ. Vel ſint α, β, γ, δ, ε, ζ, η, &c. æquales A, $A2$, $A3$, $A4$, $A5$, $A6$, $A7$, &c. Eritque $A = \alpha$, $B = \beta - \alpha$, $C = \gamma - 2\beta + \alpha$, $D = \delta - 3\gamma + 3\beta - \alpha$, $E = \varepsilon - 4\delta + 6\gamma - 4\beta + \alpha$, $F = \zeta - 5\varepsilon + 10\delta - 10\gamma + 5\beta - \alpha$, $G = \eta - 6\zeta + 15\varepsilon - 20\delta + 15\gamma - 6\beta + \alpha$, &c. In hiſce valoribus numerales Coefficientes ipſorum α, β, γ, δ, ε, &c. generantur ut in Dignitatibus integris Binomii $\overline{1-z}|^0$, $\overline{1-z}|^1$, $\overline{1-z}|^2$, $\overline{1-z}|^3$, $\overline{1-z}|^4$, &c. Scribendo numeros 1, 2, 3, 4, 5, &c. in Serie $1 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} \times \frac{n-4}{5} \times$ &c. ſucceſſivè pro n. Sit jam PQ quælibet Ordinata reliquis intermedia, & AP ejus diſtantia ab Ordinata prima A appelletur z, tum erit

$$PQ = A + B \times \frac{z}{1} + C \times$$

$$C\times\frac{z}{1}\times\frac{z-1}{2}+$$

$$D\times\frac{z}{1}\times\frac{z-1}{2}\times\frac{z-2}{3}+$$

$$E\times\frac{z}{1}\times\frac{z-1}{2}\times\frac{z-2}{3}\times\frac{z-3}{4}+$$

$$F\times\frac{z}{1}\times\frac{z-1}{2}\times\frac{z-2}{3}\times\frac{z-3}{4}\times\frac{z-4}{5}+$$

$$G\times\frac{z}{1}\times\frac{z-1}{2}\times\frac{z-2}{3}\times\frac{z-3}{4}\times\frac{z-4}{5}\times\frac{z-5}{6}+\&c.$$

Adeoque ſignum ipſius z mutandum eſt, quando $P\,Q$ cadit ad alteras Ordinatæ primæ, ut $p\,q$.

Caſus 2.] Sit jam $A5$ Ordinata in medio omnium; pone $A=B4+B5$, $B=D3+D4$, $C=F2+F3$, $D=H+H2$, *&c.* & $a=C4$, $b=E3$, $c=G2$, $d=I$, *&c.* id eſt, ſi ſint $A6=\alpha$, $A7=\beta$, $A8=\gamma$, $A9=\delta$, *&c.* $A4=\varkappa$, $A3=\lambda$, $A2=\mu$, $A=\nu$, *&c.* Pone $A=\alpha-\varkappa$, $B=\beta-2\alpha+2\varkappa-\lambda$, $C=\gamma-4\beta+5\alpha-5\varkappa+4\lambda-\mu$, $D=\delta-6\gamma+14\beta-14\alpha+14\varkappa-14\lambda+6\mu-\nu$, *&c.* $a=\alpha-2A5+\varkappa$, $b=\beta-4\alpha+6A5-4\varkappa+\lambda$, $c=\gamma-6\beta+15\alpha-20A5+15\varkappa-6\lambda+\mu$, $d=\delta-8\gamma+28\beta-56\alpha+70A5-56\varkappa+28\lambda-8\mu+\nu$, *&c.* Et dicatur $A5\,P$, z, tum erit

$$PQ=A5+\frac{Az+azz}{1.2}+$$

$$\frac{2B+bzz}{1.2}\times\frac{zz-1}{3.4}+$$

$$\frac{3Cz+czz}{1.2}\times\frac{zz-1}{3.4}\times\frac{zz-4}{5.6}+$$

$$\frac{4Dz+dzz}{1.2}\times\frac{zz-1}{3.4}\times\frac{zz-4}{5.6}\times\frac{zz-9}{7.8}+$$

$$\frac{5Ez+ezz}{1.2}\times\frac{zz-1}{3.4}\times\frac{zz-4}{5.6}\times\frac{zz-9}{7.8}\times\frac{zz-16}{9.10}+\&c.$$

Caſus

Caſus 3.] Sint jam $A4$, $A5$, Ordinatæ duæ in medio omnium. Pone

$$A = \frac{A4 + A5}{2},\ B = \frac{C3 + C4}{2},\ C = \frac{E2 + E3}{2},\ D = \frac{G + G2}{2},\ \&c.$$

$a = B4$, $b = D3$, $c = F2$, $d = H$, &c. Vel ſint $A5 = \alpha$, $A6 = \beta$, $A7 = \gamma$, $A8 = \delta$, $A4 = \varkappa$, $A3 = \lambda$, $A2 = \mu$, $A = \nu$, &c. Deinde erunt $2A = \alpha + \varkappa$, $2B = \beta - \alpha - \varkappa + \lambda$, $2C = \gamma - 3\beta + 2\alpha + 2\varkappa - 3\lambda + \mu$, $2D = \delta - 5\gamma + 9\beta - 5\alpha - 4\varkappa + 9\lambda - 5\mu + \nu$, &c. Et $a = \alpha - \varkappa$, $b = \beta - 3\alpha + 3\varkappa - \lambda$, $c = \gamma - 5\beta + 10\alpha - 10\varkappa + 5\lambda - \mu$, $d = \delta - 7\gamma + 21\beta = 35\alpha + 35\varkappa - 21\lambda + 7\mu - \nu$, &c. Et ſit O punctum medium inter $A4$, $A5$, atque appelletur OP, z; eritque Ordinata

$$PQ = \frac{A + az}{4^0} +$$
$$\frac{3B + bz}{4^1} \times \frac{4zz - 1}{2 \cdot 3} +$$
$$\frac{5C + cz}{4^2} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} +$$
$$\frac{7D + dz}{4^3} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} \times \frac{4zz - 25}{6 \cdot 7} +$$
$$\frac{9E + ez}{4^4} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} \times \frac{4zz - 25}{6 \cdot 7} \times \frac{4zz - 49}{8 \cdot 9} + \&c.$$

In hiſce duobus etiam caſibus z eſt negativa, quando Ordinata PQ cadit ad alteras partes initii Abſciſſæ. Et in omnibus tribus caſibus diſtantia communis Ordinatarum ponitur unitas.

Omnes tres caſus demonſtrantur facillime per calculum. In caſu primo pro PQ ſcribo ſucceſſive α, β, γ, δ, ε, &c. & pro z interea 0, 1, 2, 3, 4, &c. quæ ſunt longitudines Abſciſſæ ordine ſequentes; & provenient Æquationes.

$\alpha = A$, $\beta = A + B$, $\gamma = A + 2B + C$, $\delta = A + 3B + 3C + D$, $\varepsilon = A + 4B + 6C + 4D + E$, &c.

$\beta - \alpha = B$, $\gamma - \beta = B + C$, $\delta - \gamma = A + 2C + D$, $\varepsilon - \delta = B + 3C + 3D + E$, &c.

$\gamma - 2\beta + \alpha = C$, $\delta - 2\gamma + \beta = C + D$, $\varepsilon - 2\delta + \gamma = C + 2D + E$, &c.

$\delta - 3\gamma + 3\beta - \alpha = D$, $\varepsilon - 3\delta + 3\gamma - \beta = D + E$, &c.
$\varepsilon - 4\delta + 6\gamma - 4\beta + \alpha = E$, &c.

Hæ Æquationes, capiendo earum Differentias, nullo labore reſolvuntur, uti videre eſt. Et dant eoſdem ipſorum *A*, *B*, *C*, *D*, &c. valores, qui antea poſiti ſunt in ſolutione. Et ad eundem modum demonſtrantur caſus duo reliqui.

Harum trium Serierum unaquæque converget ad valorem Ordinatæ *P Q*, ubi Ordinatarum datarum Differentiæ ſunt juſtæ Magnitudinis. At ubi non convergunt, aliæ artes adhibendæ ſunt. Sed impræſentiarum de hujus Propoſitionis uſu pauca adjiciamus.

Deſignent α, β, γ, δ, ε, ζ, η, θ, $\varkappa$, λ, &c. terminos quoſcunque æquidiſtantes, quorum Differentiæ ſunt perexiguæ; & Relationes quas inter ſe obtinent definientur quamproximè per Æquationes ſequentes, quæ oriuntur capiendo Differentias & Differentias Differentiarum continuò, & ponendo eas æquales nihilo.

$\alpha - \beta = 0$
$\alpha - 2\beta + \gamma = 0$
$\alpha - 3\beta + 3\gamma - \delta = 0$
$\alpha - 4\beta + 6\gamma - 4\delta + \varepsilon = 0$
$\alpha - 5\beta + 10\gamma - 10\delta + 5\varepsilon - \zeta = 0$
$\alpha - 6\beta + 15\gamma - 20\delta + 15\varepsilon - 6\zeta + \eta = 0$
$\alpha - 7\beta + 21\gamma - 35\delta + 35\varepsilon - 21\zeta + 7\eta - \theta = 0$
$\alpha - 8\beta + 28\gamma - 56\delta + 70\varepsilon - 56\zeta + 28\eta - 8\theta + \varkappa = 0$
$\alpha - 9\beta + 36\gamma - 84\delta + 126\varepsilon - 126\zeta + 84\eta - 36\theta + 9\varkappa - \lambda = 0$.
&c.

Hæc Tabula in uſum reſervanda eſt, ut conſulatur quoties opus ſit. Quod autem hæ Æquationes vel obtinent accurate, vel ad verum approximant, ubi Differentiæ terminorum ſunt parvæ, patet ex Demonſtratione caſus primi Propoſitionis.

Aſſumatur quælibet Series $\frac{1}{101}$, $\frac{1}{102}$, $\frac{1}{103}$, $\frac{1}{104}$, $\frac{1}{105}$, $\frac{1}{106}$, &c. Et quæratur terminus qui ſtat proximus ante $\frac{1}{101}$: patet quod ille eſt $\frac{1}{100}$; videamus ergo qualem hæc Methodus exhibebit eundem. Repræſentet α terminum quæſitum, eritque

$\frac{1}{101}$

$\frac{1}{101}\beta = 0099,0099,0099,0,$
$\frac{1}{102}\gamma = 0098,0392,1568,7,$
$\frac{1}{103}\delta = 0097,0873,7864,1,$
$\frac{1}{104}\varepsilon = 0096,1538,4615,4,$
$\frac{1}{105}\zeta = 0095,2380,9523,8,$
$\frac{1}{106}\eta = 0094,3396,2264,2,$

Æquatio. { 1ma, 2da, 3tia, 4ta, 5ta, 6ta } dat α { 0099,0099,0099,0, 0099,9805,8629,3, 0099,9994,3455,0, 0099,9999,7824,8, 0099,9999,9895,8, 0099,9999,9993,1.

Patet ergo quod hæc Methodus continuè approximat. Si terminorum Differentiæ fuiſſent minores, valores acceſſiſſent citius ad verum, & contra tardius quando Differentiæ ſunt majores. Hinc ſi in Tabulis numericis deſit terminus, poteſt is per hanc Methodum inſeri.

Hoc modo etiam prodeunt ipſiſſimæ Series ſpecioſæ, quæ per alias Methodos prodire ſolent. Proponatur $\overline{1+zz}|^{-1}$ Ordinata Curvæ quadrandæ: Ea eſt prima in Serie regulari $\overline{1+zz}|^{-1}$, $\overline{1+zz}|^{0}$, $\overline{1+zz}|^{1}$, $\overline{1+zz}|^{2}$, $\overline{1+zz}|^{3}$, &c. Ordinatarum, quæ omnes præter primam dant ſuas Areas z, $z+\frac{1}{3}z^3$, $z+\frac{2}{3}z^3+\frac{1}{5}z^5$, $z+\frac{3}{3}z^3+\frac{3}{5}z^5+\frac{1}{7}z^7$, &c. conſtituentes novam Seriem cujus primus terminus erit Area quæſita: quæ ideo invenietur ponendo pro eâ α, & pro reliquis in ſuo Ordine β, γ, δ, ε, &c. Prima Æquatio dat $\alpha = z$, ſecunda $\alpha = z-\frac{1}{3}z^3$, tertia $\alpha = z-\frac{1}{3}z^3+\frac{1}{5}z^5$, quarta $\alpha = z-\frac{1}{3}z^3+\frac{1}{5}z^5-\frac{1}{7}z^7$, &c. Eſt ergo univerſim Area quæſita $z-\frac{1}{3}z^3+\frac{1}{5}z^5+\frac{1}{7}z^7+\frac{1}{9}z^9-\frac{1}{11}z^{11}$, &c. Eſtque hæc Series arcus ad Tangentem z, in circulo Radium habente unitati æqualem. Eam invenit *Jacobus Gregorius* noſter, & cum *Collinio* communicavit initio anni 1671. à quo, mediante *Oldenburgo* ad *Leibnitium* delata eſt.

Sit jam &c. e, d, c, b, a, P, α, β, γ, δ, ε, &c. Series utrinque excurrens in infinitum, ubi dantur omnes termini præter P in medio omnium. Sit $A = \alpha + a$, $B = \beta + b$, $C = \gamma + c$, $D = \delta + d$, $E = \varepsilon + e$, &c. atque erit.

$$P = \frac{A}{2} + \frac{A-B}{6} + \frac{5A-8B+3C}{60} +$$

$$\frac{7A-14B+9C-2D}{140}+$$

$$\frac{42A-96B+81C-32D+5E}{1260}+$$

$$\frac{66A-165B+165C-88D+25E-3F}{2772}+$$

$$\frac{429A-1144B+1287C-832D+325E-72F+7G}{24024}+\text{ \&c.}$$

Inveſtigatur hæc Series ex Æquationibus, excerpendo alternas in quibus numerus terminorum eſt impar. Nam earum differentiæ relinquent terminos in hac Serie; quæ itaque ad libitum produci poteſt.

Sit $\overline{1+z}|^{-1}$ Ordinata Hyperbolæ, & quæratur Area ejus quæ jacet ſupra Abſciſſam z, quando ea invadit unitas. Hæc Ordinata eſt media in Serie Ordinatarum, &c. $\overline{1+z}|^{-5}$, $\overline{1+z}|^{-4}$, $\overline{1+z}|^{-3}$, $\overline{1+z}|^{-2}$, $\overline{1+z}|^{-1}$, $\overline{1+z}|^{-0}$, $\overline{1+z}|^{1}$, $\overline{1+z}|^{2}$, $\overline{1+z}|^{3}$, &c. æquidiſtantium, hinc inde excurrente in infinitum. Adeoque Areæ ab hiſce Ordinatis genitæ conſtituent Seriem conſimilem, cujus medius terminus erit Area quæſita; quæ proinde obtinebitur per Seriem modo expoſitam. Quando z eſt unitas, ut in caſu præſente, Areæ Curvarum evadunt &c. $\frac{5}{64}$, $\frac{7}{24}$, $\frac{3}{8}$, $\frac{1}{2}$, & 1, $\frac{1}{2}$, $\frac{7}{3}$, $\frac{15}{4}$, &c. Hinc eſt $A=1+\frac{1}{2}=\frac{3}{2}$, $B=\frac{1}{2}+\frac{1}{8}=\frac{5}{8}$, $C=\frac{7}{3}+\frac{7}{24}=\frac{21}{8}$, $D=\frac{15}{4}+\frac{15}{64}=\frac{255}{64}$, &c. Hiſce in Serie ſubſtitutis, prodit P, id eſt, Area Hyperbolæ, $\frac{1}{4}$, $-\frac{1}{48}+\frac{3}{480}-\frac{4}{4480}+$ &c. id eſt, $\frac{1}{4}-\frac{A}{4\cdot 3}-\frac{2B}{4\cdot 5}-\frac{3C}{4\cdot 7}-\frac{4D}{4\cdot 9}-\frac{5E}{4\cdot 11}-$ &c. Ubi jam A, B, C, D, &c. more *Newtoniano*, deſignant terminos in ſuo Ordine ab initio. Calculum appono.

TER-

TERMINI.

Affirmativi.	*Negativi.*
7500,0000,0000,0000,0	0625,0000,0000,0000,0
62,5000,0000,0000,0	6,6964,2857,1428,5
7440,4761,9047,6	845,5086,5800,8
97,5586,9130,8	11,3818,4731,9
1,3390,4086,1	1585,7062,8
188,7745,5	22,5708,7
2,7085,0	3260,2
393,4	47,5
5,7	7
+7563,2539,3930,7494,1	−0631,7821,3370,8041,1

Summam negativam ſubducens ab affirmativâ, habeo pro Areâ, id eſt, pro Logarithmo Hyperbolico Binarii, numerum 6931,4718,0559, 9453.

Pro conſtructione Tabularum quarumvis Numericarum percommoda eſt Series quæ ſequitur. Deſignent &c. e, d, c, b, a, α, β, γ, δ, ε, &c. terminos alternos in Serie utrinque ſerpente in infinitum; Pone $A = \alpha + a$, $B = \beta + b$, $C = \gamma + c$, $D = \delta + d$, $E = \varepsilon + e$, &c. Et terminus inter α & a erit.

$$\frac{A}{2} + \frac{1}{1} \times \frac{A-B}{2^4} + \frac{1 \cdot 3}{1 \cdot 2} \times \frac{2A-3B+C}{2^7} + \frac{1 \cdot 3 \cdot 5}{1 \cdot 2 \cdot 3} \times \frac{5A-9B+5C-D}{2^{10}} + \frac{1 \cdot 3 \cdot 5 \cdot 7}{1 \cdot 2 \cdot 3 \cdot 4} \times \frac{14A-28B+20C-7D+E}{2^{13}} + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} \times \frac{42A-90B+75C-35D+9E-F}{2^{16}} +$$

$$\frac{1.3.5.7.9.11}{1.2.3.4.5.6} \times \frac{132A - 297B + 275C - 154D + 54E - 11F + G}{2^{19}} +$$

&c.

Hæc Series ſequitur ex caſu tertio Propoſitionis, ponendo $z = 0$. Coefficientes numerales Literarum ſic producuntur; exempli gratiâ, in quarto termino coefficiens Literæ penultimæ C eſt 5; pone $5 + 1 = n$, & numeri qui proveniunt ex Multiplicatione terminorum $1 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} \times \frac{n-4}{5} \times$ &c. erunt 1, 6, 15, 20, &c. Horum Differentiæ 5, 9, 5, ſunt numeri quæſiti. Atque adeo Series ad libitum produci poteſt.

Datis Logarithmis numerorum 46, 48, 50, 52, 54, 56, 58 & 60; invenire Logarithmum numeri 53, qui conſiſtit in medio omnium. Pone $l, 52 + l, 54 = A = 3, 4483, 9710, 34$, $l, 50 + l, 56 = B = 3, 4471, 5803, 13$, $l, 48 + l, 58 = C = 3, 4446, 6923, 08$, $l, 46 + l, 60 = D = 3, 4409, 0908, 19$. Hiſce valoribus in Serie ſcriptis, primi quatuor termini dabunt 1,7242,2586,96 pro Logarithmo numeri 53. Et eadem ratione invenire licet quemvis alium intermedium.

In Conſtructione ergo Tabularum ſufficit primo quærere aliquos terminos in debitis diſtantiis, nam reliqui poſſunt hoc modo interſeri. Etenim continuo ſunt intercalandi termini primo inventi, uſque dum perventum fuerit ad ultimos qui deſiderantur. Hoc modo habebitur tota Tabula ex datis paucis terminis ſub initio pro fundamento operationis. Sed non convenit ut termini quos primo quærimus, ſint omnes per totam Tabulam æquidiſtantes; nam ſi omittimus alternos ubi eorum differentia eſt maxima, poſſumus alibi per ſaltum omittere duos, tres, viginti aut forte plures terminos. Numerus autem terminorum inter duos datos conſiſtentium, qui omittuntur, debet ſemper eſſe aliquis ſequentium 1, 3, 7, 15, 31, 63, &c. dummodo volumus inſerere eos per hanc Seriem; hoc vero neutiquam incommodabit opus.

Poſſunt autem pro Praxi termini in unam ſummam colligi, ut factum vides in hac Tabella. Prima expreſſio eſt primus terminus; ſecunda eſt ſumma primi & ſecundi; tertia eſt ſumma primi, ſecundi & tertii: & ſic porro.

$$2 \left| \frac{A}{2} \right.$$

$9A -$

$$
\begin{array}{r|l}
 & 9A-B \\
4 & \hline \\
 & 16 \\
 & 150A-25B+3C \\
6 & \hline \\
 & 256 \\
 & 1225A-245B+49C-5D \\
8 & \hline \\
 & 2048 \\
 & 39690A-8820B+2268C-305D+35E \\
10 & \hline \\
 & 65536
\end{array}
$$

Sic datis aliquibus terminis alternis, intermedii confeſtim dabuntur per haſce Expreſſiones, nullâ ratione habitâ naturæ Tabulæ particularis. Nam hæ regulæ ſunt eædem in omnibus. Areæ curvarum ſunt proxime æquales Areis Parabolicæ figuræ quæ tranſit per extrema Ordinatarum ſuarum. Sed quoniam laborioſum nimis eſſet ſemper recurrere ad Parabolam, computavi Tabulam ſequentem, quâ Areæ directe exhibentur ex datis Ordinatis.

$$
\begin{array}{r|l}
 & A \\
1 & -R \\
 & 1 \\
 & A+4B \\
3 & \hline \\
 & 6 \\
 & 7A+32B+12C \\
5 & \hline \\
 & 90 \\
 & 41A+216B+27C+272D \\
7 & \hline \\
 & 840 \\
 & 989A+5888B-928C+10496D-4540E \\
9 & \hline \\
 & 28350 \\
 & 16067A+106300B-48525C+272400D-260550E+427368F \\
11 & \hline \\
 & 598752
\end{array}
$$

Hic numerus Ordinatarum eſt impar, A eſt ſumma primæ & ultimæ, B ſecundæ & penultimæ, C tertiæ & antepenultimæ; & ſic porro, uſque dum deventum ſit ad eam in medio omnium, quæ per ultimam literam in quâque expreſſione repræſentatur. R eſt Baſis ſeu pars Abſciſſæ

ſciſſæ inter primam & ultimam Ordinatam interceptæ. Expreſſiones ſunt Areæ contentæ inter Curvam, Baſin & Ordinatas hinc inde extremas. Tabulam pro pare numero Ordinatarum non appoſui, quoniam Area cæteris paribus ex impare earum numero accuratius definitur.

Quæratur Area quæ generatur ab Ordinatâ $\overline{1+zz}^{-1}$, & jacet ſupra Abſciſſam z quando ea invadit unitas. In $\overline{1+zz}^{-1}$, pro z ſcribe $\frac{0}{10}, \frac{1}{10}, \frac{2}{10}, \frac{3}{10}, \frac{4}{10}, \frac{5}{10}, \frac{6}{10}, \frac{7}{10}, \frac{8}{10}, \frac{9}{10}, \frac{10}{10}$; & prodibunt undecim Ordinatæ $1, \frac{100}{101}, \frac{25}{26}, \frac{100}{109}, \frac{25}{29}, \frac{4}{5}, \frac{25}{34}, \frac{100}{149}, \frac{25}{41}, \frac{100}{181}, \frac{1}{2}$. Hinc eſt $A = 1 + \frac{1}{2} = \frac{3}{2}$, $B = \frac{100}{101} + \frac{100}{181} = \frac{28800}{18281}$, $C = \frac{25}{26} + \frac{25}{41} = \frac{1675}{1066}$, $D = \frac{100}{109} + \frac{100}{149} = \frac{25800}{16241}$, $E = \frac{25}{29} + \frac{25}{34} = \frac{1575}{986}$, $F = \frac{4}{5}$. Hiſce valoribus ſubſtitutis in ultimâ Expreſſione, & Unitate pro R, invenies Aream eſſe 785398187. Juſtus eſt hic numerus in ſeptimâ Figurâ, in octavâ verum ſuperans Binario.

Si undecim Ordinatæ non dent Aream ſatis exactam, erige plures; & concipe Aream diviſam eſſe in plures Partes, quarum quamque ſeorſum quærens habebis pro lubitu juſtam.

Valor ipſius $\overline{1+\mathcal{Q}}^{n}$ exprimi poteſt per quamcunque trium Serierum ſequentium.

$$\overline{1+\mathcal{Q}}^{n} = 1 + \mathcal{Q} \times \frac{n}{1} +$$

$$\mathcal{Q}^2 \times \frac{n}{1} \times \frac{n-1}{2} +$$

$$\mathcal{Q}^3 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} +$$

$$\mathcal{Q}^4 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} +$$

$$\mathcal{Q}^5 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} \times \frac{n-4}{5} + \&c.$$

Vel $\overline{1+\mathcal{Q}}^{n} = 1 + R \times \frac{n}{1} +$

$R^2 \times$

$$R^1 \times \frac{n}{1} \times \frac{n+1}{2} +$$

$$R^3 \times \frac{n}{1} \times \frac{n+1}{2} \times \frac{n+2}{3} +$$

$$R^4 \times \frac{n}{1} \times \frac{n+1}{2} \times \frac{n+2}{3} \times \frac{n+3}{4} +$$

$$R^5 \times \frac{n}{1} \times \frac{n+1}{2} \times \frac{n+2}{3} \times \frac{n+3}{4} \times \frac{n+4}{5} + \&c.$$

Posito scilicet $R = \frac{1+Q}{Q}$. Vel

$$\overline{1+Q}^n = 1 + \frac{2+\overline{n+1} \times Q}{\overline{1+Q}^1} \times Q \times \frac{n}{1.2} +$$

$$\frac{4+\overline{n+2} \times Q}{\overline{1+Q}^2} \times Q^3 \times \frac{n}{1.2} \times \frac{nn-1}{3.4} +$$

$$\frac{6+\overline{n+3} \times Q}{\overline{1+Q}^3} \times Q^5 \times \frac{n}{1.2} \times \frac{nn-1}{3.4} \times \frac{nn-4}{5.6} +$$

$$\frac{8+\overline{n+4} \times Q}{\overline{1+Q}^4} \times Q^7 \times \frac{n}{1.2} \times \frac{nn-1}{3.4} \times \frac{nn-4}{5.6} \times \frac{nn-9}{7.8} +$$

$$\frac{10+\overline{n+5} \times Q^5}{\overline{1+Q}^5} \times Q^9 \times \frac{n}{1.2} \times \frac{nn-1}{3.4} \times \frac{nn-4}{5.6} \times \frac{nn-9}{7.8} \times \frac{nn-16}{9.10}$$

$$+ \&c.$$

Primæ duæ Series demonstrantur per Casum primum Propositionis.

Nam si $\overline{1+Q}^0$, $\overline{1+Q}^1$, $\overline{1+Q}^2$, $\overline{1+Q}^3$, $\overline{1+Q}^4$, &c. designent Ordinatas

Ordinatas totidem æquidiſtantes in Parabolica figurâ, erit $\overline{1+z}|^r$ ejuſdem Ordinata, cujus diſtantia à $\overline{1+z}|^0$ eſt n. Et ſic prodit Series prima. At ſi in alia Parabola $\overline{1+z}|^0$, $\overline{1+z}|^{-1}$, $\overline{1+z}|^{-2}$, $\overline{1+z}|^{-3}$, $\overline{1+z}|^{-4}$, *&c.* ſint æquidiſtantes Ordinatæ, erit $\overline{1+z}|^r$ Ordinata in eadem, cujus diſtantia à $\overline{1+z}|^0$ eſt $-n$; ſic proveniet Series ſecunda. Sit jam in tertia Parabola, *&c.* $\overline{1+z}|^{-4}$, $\overline{1+z}|^{-3}$, $\overline{1+z}|^{-2}$, $\overline{1+z}|^{-1}$, $\overline{1+z}|^0$, $\overline{1+z}|^1$, $\overline{1+z}|^2$, $\overline{1+z}|^3$, $\overline{1+z}|^4$, *&c.* Series Ordinatarum æquidiſtantium hinc inde progrediens in infinitum, eritque in eadem $\overline{1+z}|^n$ Ordinata, diſtantia n à termino medio $\overline{1+z}|^0$ remota. Et ſic provenit Series tertia per Caſum ſecundum Propoſitionis. Prima abrumpit quando eſt n integer & affirmativus, ſecunda quando eſt n integer & negativus, & tertia in caſu utroque abrumpit. Per harum quamque radices numerales commode evolvuntur in Series. Tertia reliquis multo citius convergit: Ejus terminus ſecundus adhiberi poteſt pro correctione, ubi fit extractio per Repetitionem calculi.

Halleius in ſua Methodo conſtruendi Logarithmos, ex prima harum Serierum demonſtrat Seriem *Mercatoris* pro Quadratura Hyperbolæ. Sit ejus Ordinata $\overline{1+z}|^{n-1}$, vel $\overline{1+z}^{n-1}$, exiſtente n numero infinite parvo; unde per Methodos Quadrandi, Area quæ jacet ſupra Abſciſſam z, id eſt, Logarithmus numeri $1+z$, erit $\frac{\overline{1-z}|^{n-1}}{n}$. Eſt vero per primam Seriem $\overline{1+z}|^n = 1 + \frac{n}{1}z + \frac{n}{1}\times\frac{n-1}{2}z^2 + \frac{n}{1}\times\frac{n-1}{2}\times\frac{n-2}{3}z^3 + \&c.$ adeoque in caſu præſente, ubi eſt n infinite parvus, eſt $\overline{1+z}|^n = 1 + \frac{n}{1}z - \frac{n}{2}z^2 + \frac{n}{3}z^3 - \frac{n}{4}z^4 + z^5$ *&c.* quo ſubſtituto in valore Areæ, ea prodit $z - \frac{1}{2}z^2 + \frac{1}{3}z^3 - \frac{1}{4}z^4 + \frac{1}{5}z^5 - \&c.$ quæ eſt Series *Mercatoris*.

Similiter per Seriem ſecundam prodit hæc regula; Sit datus numerus

rus $1+z$, pone $R=\frac{z}{1+z}$, eritque ejus Logarithmus $R+\frac{1}{2}R^2+\frac{1}{3}R^3+\frac{1}{4}R^4+\frac{1}{5}R^5+$ &c.

Per Seriem tertiam provenit ſequens regula. Sit quilibet numerus R, pone $z=\frac{\overline{R-1}|^2}{2R}$, eritque ejus Logarithmus $\frac{RR-1}{2R}-\frac{1}{3}Az-\frac{2}{5}Bz-\frac{1}{7}Cz-\frac{4}{9}Dz-\frac{5}{11}Ez-$ &c. Ubi A, B, C, D, E, &c. more *Newtoniano* deſignant terminos Seriei ſicut ab initio. Hæc Series, ut ea ex qua ea deducitur, reliquis duabus multis vicibus celerius approximat: eſtque eadem generalius expreſſa quam, ex fundamento haud abſimili, pro inventione Logarithmi Binarii prius dedimus.

Methodus inveniendi valores Serierum Arithmeticarum utcunque tarde convergentium.] In aliquibus Seriebus ſumma terminorum haberi nequit niſi ad pauciſſima figurarum loca, dummodo præter ſimplicem eorum additionem aliæ artes non adhibeantur. Proponatur jam Series quælibet cujus termini omnes iiſdem ſignis afficiuntur, & quorum proximi continue tendunt eſſe inter ſe æquales; quales ſunt ſequentes $\frac{1}{1\cdot3}+\frac{1}{3\cdot4}+\frac{1}{5\cdot6}+\frac{1}{7\cdot8}+$ &c. $1+\frac{1}{4}+\frac{1}{9}+\frac{1}{16}+\frac{1}{25}+$ &c. Collige ſummam aliquot terminorum ſub initio, ii proxime addendi ſint α, β, γ, δ, ε, ζ, &c. In numeris proximis ſit $r=\frac{\alpha\gamma-\beta\beta}{\alpha\beta-2\alpha\gamma+\beta\gamma}$, & quantitatum $\alpha\times\frac{\alpha+r\beta}{\alpha-\beta}$, $\alpha+\beta\times\frac{\beta+r\gamma}{\beta-\gamma}$, $\alpha+\beta+\gamma\times\frac{\gamma+r\delta}{\gamma-\delta}$, $\alpha+\beta+\gamma+\delta\times\frac{\delta+r\varepsilon}{\delta-\varepsilon}$, $\alpha+\beta+\gamma+\varepsilon\times\frac{\varepsilon+r\zeta}{\varepsilon-\zeta}$, &c. Differentiæ ſint a, b, c, d, e, &c. Deinde in numeris proximis ſit $s=\frac{ac-bb}{ab-2ac+bc}$, & ipſorum $a\times\frac{a+sb}{a-b}$, $a+b\times\frac{b+sc}{b-c}$, $a+b+c\times\frac{c+sd}{c-d}$, $a+b+c+d\times\frac{d+se}{d-e}$, &c.

&c. differentiæ ſint A, B, C, D, &c. ſit $t = \frac{AC-BB}{AB-2AC+BC}$: atque ſic procede quoad libuerit. Tum erit $\alpha+\beta+\gamma+\delta+\varepsilon+$ &c. $= \alpha \times \frac{\alpha+r\beta}{\alpha-\beta} + a \times \frac{a+sb}{a-b} + A \times \frac{A+tB}{A-B}$ + &c. atque ultra duos primos terminos hujus novæ Seriei raro opus erit progredi.

Ut ſi deſideretur valor Seriei $\frac{1}{1.2} + \frac{1}{3.4} + \frac{1}{5.6} + \frac{1}{7.8}$ + &c. collige primos 21 terminos, quorum ſummam reperio fore 6813, 8410, 1885. Termini proxime addendi ſunt $\alpha = ,0005,2854,1226, \beta = ,0004, 8309,1787, \gamma = ,0004,4326,2411, \delta = ,0004,0816,3265$, &c. Hinc fit $r = 1$ proxime, & $\alpha \times \frac{\alpha+r\beta}{\alpha-\beta} = ,0117,6449,6282, a = -,0000,0017, 5096, b = -,0000,0014,7410, c = -0000,0012,4986$, &c. Unde $s = \frac{1}{5}$ prope, & $a \times \frac{a+sb}{a-b} = 0000,0141,8111$, quem propter ſignum negativum ſubduco ab $\alpha \times \frac{\alpha+\beta}{\alpha-\beta}$, & remanet, 0117, 6307,8171: hic additus ſummæ primo inventæ 6813,8410,1885, dat pro ſumma totius Seriei numerum 6931,4718,0056. qui juſtus eſt in nonâ decimali; at ante duas haſce correctiones ſumma erat juſta in primâ figurâ ſolâ. Si animus ſit propius ſcopum attingere, pergendum erit ad approximationes ſequentes. Si termini Seriei diverſa habeant ſigna, conjungendi ſunt, ut omnes eadem tandem habeant, ut in Serie $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} -$ &c. conjunctis terminis ea evadit $\frac{2}{1.3} + \frac{2}{5.7} + \frac{2}{9.11} + \frac{2}{13.15} +$ &c. Sed hic notandum eſt quod differentiæ a, b, c, d, e, &c. ut & A, B, C, D, &c. colligi debent ſubducendo quantitates antecedentes de ſubſequentibus. Et in omnibus hujuſmodi Seriebus ſi p, q, r, repræſentent tres terminos ordine ſequentes, p primum, q ſecundum, r tertium, & rectangulum $p+r$

$\frac{p+r}{2} \times q$ non ſit majus $p\,r$, valor Seriei erit infinite magnus: at magnitudinis ſemper finitæ ubi accidit contrarium. Poteſt hæc regula nonnunquam fallere, ubi termini p, q, r parum diſtant ab initio Seriei, at ſi conſiſtant inter eos ab initio aliquantum remotos, evadet regula certiſſima.

Ad alia Serierum genera debent aliæ regulæ adhiberi. Sit Series regularium Polygonorum Circulo Inſcriptorum, exiſtente Radio unitate.

$H = 2,0000,0000,0000,000$	4
$G = 2,8284,2712,4746,190$	8
$F = 3,0614,6745,8920,718$	16
$E = 3,1214,4515,2258,051$	32
$D = 3,1365,4849,0545,938$	64
$C = 3,1403,3115,6954,752$	128
$B = 3,1412,7725,0932,772$	256
$A = 3,1415,1380,1144,299$	512

Dicatur jam ultimum Polygonum A, penultimum B, antepenultimum C, & reliqua in ſuo ordine retrorſum D, E, F, &c. atque area Circuli quæſita erit $A + \frac{A-B}{3} + \frac{4A-5B+C}{3 \cdot 15} + \frac{64A-84B+21C-D}{3 \cdot 15 \cdot 63} +$

$\frac{4096A-5440B+1428C-85D+E}{3 \cdot 15 \cdot 63 \cdot 255} +$ &c. Ubi ſi pro A, B, C, D, E, &c. ſcribantur proprii valores, primi quatuor termini dabunt 3, 1415, 9265, 3589, 790 pro area Circuli. Hæc autem Series eſt generalis, ex natura Circuli neutiquam dependens: applicabilis eſt quotieſcunque numerorum approximantium differentiæ priores ſunt poſteriorum quaſi quadruplæ. Factores in Denominatoribus ſunt dignitates integræ numeri 4 unitatibus minutæ: quibus datis, Coefficientes literarum in diverſis terminis formantur ex multiplicatione continua numerorum 1, $\frac{n}{3}$, $\frac{n-3}{15}$, $\frac{n-15}{63}$, $\frac{n-63}{255}$, &c. Ubi pro n ſubſtituendus eſt ultimus Factorum in Denominatore.

Ultima quantitatum $x-1$, $2\sqrt[2]{x}-2$, $4\sqrt[4]{x}-4$, $8\sqrt[8]{x}-8$, $16\sqrt[15]{x}-16$, &c. æqualis eſt Logarithmo numeri x. Pro x ſcribe 2, & per repetitam extractionem radicis quadratæ exibunt numeri.

$M = 1,0000,0000,0000,0000.$
$L = 8284,2712,4746,1901.$
$I = 7568,2864,0010,8843.$
$H = 7240,6186,1322,0613.$
$G = 7083,8051,8838,6214.$
$F = 7007,0875,6931,7337.$
$E = 6969,1430,7308,8294.$
$D = 6950,2734,2438,7611.$
$C = 6940,8641,2851,8363.$
$B = 6936,1658,4759,4014.$
$A = 6933,8182,9699,9493.$

Dicatur ultimus numerorum A, penultimus B, & ſic retro, atque Logarithmus quæſitus erit $A + \frac{A-B}{1} + \frac{2A-3B+C}{1\cdot 3} + \frac{8A-14B+7C-D}{1\cdot 3\cdot 7} + \frac{64A-120B+70C-15D+E}{1\cdot 3\cdot 7\cdot 15}$ + &c. Primi quinque termini dant 6931, 4718, 0559, 9457 pro Logarithmo Hyperbolico Binarii. Et quomodo hæc Series procedit in infinitum facile colligitur ex eo quod de priore diximus: eſtque etiam univerſalis, proprietates Hyperbolæ minime reſpiciens.

Extenditur quoque Methodus hæcce Differentialis ad Reſolutionem Æquationum & alia quam plurima quorum hic non fit mentio. Continetque fundamenta Serierum generaliſſima; ut in Reductione Æquationum Irrationalium & Fluxionalium brevi forſan monſtrabo.

A General *Method of making* Logarithms, *by M.* J. Craig. n. 328. p. 191.

XX. Ad utiliſſimam hanc Arithmeticæ partem perficiendam, hoc tantùm inveniendum ſupereſſe videatur; ut ſcil. omnes Series Logarithmicas inveniendi Methodum habeamus generalem; talis autem eſt hæc quæ ſequitur, facilis quidem illa & genuina, utpote ex ipsâ Logarithmorum Naturâ deducta.

Per Literam l numero cuilibet præfixam denotetur (ut vulgo ſolet) iſtius Numeri Logarithmus. Jam quoniam Numeri cujuſvis propoſiti Logarithmus duobus modis inveſtigari poteſt, ideo Logarithmotechniæ hujus duas partes conſtituemus: In priori Logarithmum immediatè ex ipſo numero deducimus; in poſteriori vero Numerorum aliquot antecedentium Logarithmi adhibentur, ut ex iis propoſiti Numeri Logarithmus inveniatur.

Pars Prior. Sit $a + 1$ numerus quilibet propoſitus, & x ejus Logarithmus inveniendus. Jam ex hypotheſi $x = l \cdot \overline{a + 1}$, quæ Æquatio vocetur Canon generalis. (1.) Fiat Æquatio inter terminos ex a & y utcunque compoſitos & cum aliis quibuſvis numeris quovis modo per

Additionem, Subſtractionem, Multiplicationem, Diviſionem aut Radicum Extractionem combinatos. (2.) Ope Æquationis ſic ad libitum aſſumptæ exterminetur a ex Canone generali, & habebitur Æquatio exprimens Relationem inter indeterminatos x, y. (3.) Hujus Æquationis (per regulam Bernoullianam) inveniatur Differentialis, & hujus Integralis (per Methodos notiſſimas) per Seriem infinitam expreſſa dabit Logarithmi quæſiti x valorem cognitum.

Exemplum 1. Aſſumatur $a = y$, unde per Canonem generalem $x = l.\overline{1+y}$, cujus Differentialis eſt $\dot{x} = \frac{\dot{y}}{1+y}$, & hujus integralis per Seriem infinitam expreſſa dat

$$x = y - \tfrac{1}{2}y^2 + \tfrac{1}{3}y^3 - \tfrac{1}{4}y^4 + \tfrac{1}{5}y^5 - \tfrac{1}{6}y^6 + \tfrac{1}{7}y^7 \text{ &c.}$$

Exemplum 2. Aſſumatur $y = \frac{a}{a+2}$, unde $a+1 = \frac{1+y}{1-y}$, ideoque per Canonem generalem $x = l.\frac{1+y}{1-y}$, cujus Differentialis eſt $\dot{x} = \frac{2\dot{y}}{1-yy}$; & hujus Integralis in Seriem reſoluta dat

$$x = 2 \times y + \tfrac{1}{3}y^3 + \tfrac{1}{5}y^5 + \tfrac{1}{7}y^7 + \tfrac{1}{9}y^9 \text{ &c.}$$

Ubi numerus 2 Seriei præfixus multiplicari ſupponitur in ſingulos Seriei terminos. Nec plura addere exempla opus hic erit, cum ex his pateat Methodus inveniendi innumeras Series Logarithmicas, quæ, abſque ullo ad aliorum numerorum Logarithmos reſpectu, exhibent numeri propoſiti Logarithmum. Q. E. I.

Lemma 1. Sit z Logarithmus cujuſvis Fractionis $\frac{b}{a+1}$, x Logarithmus Denominatoris $a+1$; erit $lb - z = x$: Vel ſi ſit z Logarithmus Fractionis $\frac{a+1}{b}$, erit $lb + z = x$.

Lemma 2. Sit e exponens cujuſvis poteſtatis numeri b, erit $l.\, b^e = e \times l.\, b$; ideoque datis Logarithmo numeri b^e & exponente e, datur ipſius b Logarithmus: Et ex Natura Logarithmorum conſtat utrumque Lemma.

Pars Poſterior. Sit (ut prius) $a+1$ Numerus cujus Logarithmus x eſt inveniendus, ſitque b^e Numerus productus ex Multiplicatione Numerorum, quorum maximus eſt minor quam $a+1$; & z Logarithmus

rithmus Fractionis $\frac{b}{a+1}$, id eſt $z = l.\frac{b}{a+1}$, quæ Æquatio vocetur Canon generalis. Tum (1.) pro b ſumatur quantitas ex a & numeris quibuſvis determinatis utcunque compoſita, & hic valor numeri b ſic ad libitum ſumptus ſubſtituatur in Fractione $\frac{b}{a+1}$, unde illa per a & numeros datos exprimetur. (2.) Fiat quælibet Æquatio inter y & a cum numeris ad libitum ſumendis; & ope hujus exterminetur a ex Canone generali, unde habetur Æquatio exprimens relationem inter indeterminatos z, y. (3.) Hujus Æquationis inveniatur (per Regulam Bernoullianam) Differentialis, hujuſque Integralis (juxta Methodos notiſſimas) per Seriem infinitam expreſſa dabit Fractionis $\frac{b}{a+1}$ Logarithmum z; & ex invento z habebitur (per *Lem.* 1.) numeri propoſiti $a+1$ Logarithmus $x = l.\ b - z$. Nam ex hypotheſi b^e producitur ex Multiplicatione Numerorum quorum maximus eſt minor quam $a+1$; & ex hypotheſi dantur Logarithmi omnium numerorum propoſito $a+1$ minorum, ergo & Logarithmus Numeri ex omnibus producti ſeu b^e, & proinde (per *Lem.* 2.) ipſius b Logarithmus datur.

Exemplum 1. Sumatur ſi placet $b = a$, unde $z = l.\frac{a}{a+1}$: Dein (per art. 2.) fiat ad libitum $y = 2a+1$, per hanc exterminetur a, & erit $z = l.\frac{y-1}{y+1}$, cujus Differentialis eſt $z = \frac{2\dot{y}}{yy-1}$; cujus Integralis per Seriem expreſſa dat $z = -2 \times \frac{1}{y} + \frac{1}{3y^3} + \frac{1}{5y^5} + \frac{1}{7y^7} + \&c.$ Unde per Lemma 1.

$$x = lb + 2 \times \frac{1}{y} + \frac{1}{3y^3} + \frac{1}{5y^5} + \frac{1}{7y^7} + \frac{1}{9y^9} \&c.$$

Exemplum 2. Fiat $b = \sqrt{aa+2a}$, unde $z = l.\frac{\sqrt{aa+2a}}{a+1}$, ſumatur etiam ad libitum $y = 2a+2a$, unde $z = l.\frac{1}{y}\sqrt{yy-4}$, cujus Differentialis

rentialis eſt $\dot{z} = 4\dot{y} \times \overline{y^3 - 4y}|^{-1}$, & hujus Integralis eſt $z = 2x$

$\frac{1}{y^3} + \frac{2^3}{2y^4} + \frac{2^4}{3y^6} + \frac{2^6}{4y^8}$ &c. Unde per Lemma 1.

$$x = l.\ b + 2 \times \frac{1}{y^3} + \frac{2^3}{2y^4} + \frac{2^4}{3y^6} + \frac{2^6}{4y^8} + \frac{2^8}{5y^{10}} \text{ &c.}$$

Exemplum 3. Fiat $b = \sqrt{aa + 2a}$, ut in præcedenti, ſed jam aſſumatur $y^2 = 2aa + 4aa + 1$; Si per has duas Æquationes exterminentur b & a ex Canone generali, erit $z = l\frac{\sqrt{yy-1}}{\sqrt{yy+1}}$, cujus Differentialis eſt $\dot{z} = 2y\dot{y} \times \overline{y^4 - 1}|^{-1}$; & hujus Integralis per Seriem expreſſa eſt

$z = -\frac{1}{y^2} - \frac{1}{3y^6} - \frac{1}{5y^{10}} - \frac{1}{7y^{14}}$ &c. Unde per Lem. 1.

$$x = l.\ b + \frac{1}{y^2} + \frac{1}{3y^6} + \frac{1}{5y^{10}} + \frac{1}{7y^{14}} + \frac{1}{9y^{18}} \text{ &c.}$$

Notandum verò eſt quod numerus 2. Seriebus Exemp. 1 & 2. præfixus multiplicari ſupponitur in ſingulos Serierum terminos: Similesque Series deduci poſſunt eodem modo ex $z = l.\frac{a+1}{b}$ atqui tum $x = l.\ b + z$, ut conſtat ex Lemmatis 1. parte ſecundâ. Ex his itaque ſatis ſuperque conſtat Logarithmotechniam jam expoſitam eſſe facillimam & maxime genuinam, nec-non adeo generalem ut duobus modis innumeræ Series inveniri poſſint Numeri cujuſvis propoſiti Logarithmum exhibentes: Nam innumeras (ad libitum) aſſumere licet Æquationes relationem inter y & a exprimentes, quarum unaquæque novam exhibet Seriem Logarithmicam. Summa tamen adhibenda eſt cura, ut tales aſſumantur, quæ efficient ut Serierum termini quam celerrimè convergant, i. e. ut Logarithmus quam minimo Calculi labore inveniatur: Ad hoc præſtandum perquam apta eſt Series in Exemplo poſtremo exhibita, & quæ eadem eſt cum illâ quam primus exhibuit Celeberrimus D. *Ed. Halleius* in eleganti ſuâ Logarithmos conſtruendi Methodo.

Obiter Lectorem hic monitum volo, quod Curva, quæ ex noſtrâ Problematis de Longitudine linearum Curvarum Analyſi in Actis Phil.

Vid. *Sup.* S. IX.

R. S. Anni 1708. editâ eadem ſit cum propoſitâ. Ego quidem de rectè inſtitutâ Analyſi tantum ſollicitus hanc Curvæ propoſitæ & inventæ coincidentiam minimè obſervabam, priuſquam de eâ me certiorem fecerit Clariſſ. D. Jo. Bernoulli in literis ſuis ad D. Guil. Burnetum, R. S. S. miſſis; in quibus etiam celeberrimum virum meis contra *Motum* ſuum *Reptorium* objectionibus plenè ſatisfeciſſe ex puro (quam colo) Veritatis amore libenter agnoſco.

A New *Method for making* Logarithms, *communicated by Mr.* J. Long. n. 339. p. 52.

XXI.

Log.	*Nat. Num.*
0,9	7,943282347
0,8	6,309573445
0,7	5,011872336
0,6	3,981071706
0,5	3,162277660
0,4	2,511886432
0,3	1,995262315
0,2	1,584893193
0,1	1,258925412
0,09	1,230268771
0,08	1,202264435
0,07	1,174897555
0,06	1,148153621
0,05	1,122018454
0,04	1,096478196
0,03	1,071519305
0,02	1,047128548
0,01	1,023292992
0,009	1,020939484
0,008	1,018591388
0,007	1,016248694
0,006	1,013911386
0,005	1,011579454
0,004	1,009252886
0,003	1,006931669
0,002	1,004615794
0,001	1,002305238
0,0009	1,002074475
0,0008	1,001843766
0,0007	1,001613109
0,0006	1,001382506
0,0005	1,001151956
0,0004	1,000921459
0,0003	1,000691015
0,0002	1,000460623
0,0001	1,000230285

Log.	*Nat. Num.*
0,00009	1,000207254
0,00008	1,000184224
0,00007	1,000161194
0,00006	1,000138165
0,00005	1,000115136
0,00004	1,000092106
0,00003	1,000069080
0,00002	1,000046053
0,00001	1,000023026
0,000009	1,000020724
0,000008	1,000018421
0,000007	1,000016118
0,000006	1,000013816
0,000005	1,000011513
0,000004	1,000009210
0,000003	1,000006908
0,000002	1,000004605
0,000001	1,000002302
0,0000009	1,000002072
0,0000008	1,000001842
0,0000007	1,000001611
0,0000006	1,000001381
0,0000005	1,000001151
0,0000004	1,000000921
0,0000003	1,000000690
0,0000002	1,000000460
0,0000001	1,000000230
0,00000009	1,000000207
0,00000008	1,000000184
0,00000007	1,000000161
0,00000006	1,000000138
0,00000005	1,000000115
0,00000004	1,000000092
0,00000003	1,000000069
0,00000002	1,000000046
0,00000001	1,000000023

This

This Table is what I ſometimes make uſe of for finding the Logarithm of any Number propoſed, and *vice versâ*, for finding the Number correſponding to a Logarithm given. For Inſtance: Suppoſe I had occaſion to find the Logarithm of 2000, I look in the firſt Claſs of my Table (the whole Table conſiſts of 8 Claſſes) for the next leſs to 2, which is 1.295262315, and againſt it is 3, which conſequently is the firſt Figure of the Logarithm ſought. Again; dividing the Number propoſed 2, by 1.995262315, the Number found in the Table, the Quotient is 1.002374467; which being look'd for in the ſecond Claſs of the Table, and finding neither its equal, nor a leſſer, I add 0 to the Part of the Logarithm before found, and look for the ſaid Quotient 1.002374467 in the third Claſs, where the next leſs is 1.002305238, and againſt it is 1, to be added to the Part of the Logarithm already found; and dividing the Quotient 1.002374467, by 1.002305238, laſt found in the Table, the Quotient is 1.000069070; which being ſought in the fourth Claſs gives 0, but being ſought in the fifth Claſs gives 2, to be added to the Part of the Logarithm already found; and dividing the laſt Quotient by the Number laſt found in the Table, *viz.* 1.000046053, the Quotient is 1.000023015, which being ſought in the ſixth Claſs, gives 9 to the Part of the Logarithm already found: and dividing the laſt Quotient by the new Diviſor, *viz.* 1.000002072, the Quotient is 1.000000219, which being greater than 1.000000115, ſhews that the Logarithm already found, *viz.* 3.3010299 is leſs than the Truth by more than half an Unit; wherefore adding 1, you have *Briggs*'s Logarithm of 2000, *viz.* 3.3010300.

If any Logarithm be given, ſuppoſe 3.3010300, throw away the Characteriſtic, then over againſt theſe Figures 3...0..1...0..3..6..0, you have in their reſpective Claſſes 1.995262315.....0.....1.002305238 .....0.....1.000069080....0...0 which multiplied continually into one another, the Product is 2.000000019966. which by reaſon the Characteriſtic is 3, becomes 2000.000019966, that is, 2000, the Natural Number deſired. I ſhall not mention the Method by which this Table is framed, becauſe you will eaſily ſee that from the Uſe of it.

It is obvious to the intelligent Reader, that theſe Claſſes of Numbers are no other than ſo many Scales of mean Proportionals: In the firſt Claſs, between 1 and 10; ſo that the laſt Number thereof, *viz.* 1.258925412 is the tenth Root of 10, and the reſt in order aſcending are the Powers thereof. So in the ſecond Claſs, the laſt Number 1.023292992 is the hundredth Root of 10, and the reſt in the ſame manner are Powers thereof. So 1.002305238 in the third Claſs, is the tenth Root of the laſt of the ſecond, and the reſt its Powers, *&c.* Or, which is all one, each Number in the preceding Claſs, is the tenth Power of the correſponding Number in the next following Claſs: Whence 'tis plain, that to conſtruct theſe Tables requires no more than

one Extraction of the fifth or ſurſolid Root for each Claſs, the reſt of the Work being done by the common Rules of Arithmetick; and for extracting the fifth Root, you will find more than one very compendious Rule in *Num.* 210. of theſe *Tranſactions*, if any one ſhall deſire to examine the *computus* of theſe Tables.

The Proceſs is exactly the reverſe of Mr. *Briggs*'s Doctrine, in *Cap.* XII. of his *Arithmetica Logarithmica* of *Vlacq*'s Edition; and had *Briggs* been appriz'd hereof, it would have greatly eaſed the Labour of deducing the Logarithms of the firſt prime Numbers, which appear to have coſt him ſo much Pains.

A Letter of Mr. l'Abbé Conti *to Mr.* Leibnitz, *concerning the* Invention *of the Method of* Fluxions, n. 359. p. 923.

XXII. 1. J'ay differé juſqu' à cette heure de repondre à vôtre Lettre, parce que j'ai voulu accompagner ma Réponſe de celle que M. *Newton* [a] vient de fair à l'Apoſtille que vous y avez ajoutée. Je n' entrerai dans aucun detail à l'égard de la diſpute que vous avez avec M. *Keill*, ou plutôt avec M. *Newton*. Je ne puis dire qu' hiſtoriquement ce que j'ai vû, & ce que j'ai lû, & ce qu'il me manque encore de voire & de lire, pour en juger come il faut.

J'ai lû avec beaucoup d'attention, & ſans la moindre prevention, le *Commercium Epiſtolicum*, & le petit Livre [b] qui en continent *l'Extrait*. J'ai vû à la *Societé Royale* les Papiers originaux des Lettres du *Commercium*; une petite [c] Lettre écrite de vôtre main à M. *Newton*; & l'ancien Manuſcript [d] que M. *Newton* envoya au Docteur *Barrow*, & que M. *Jones* à publié depuis peu.

De tout cela j'en infere, que ſi on ôte à la diſpute toutes les digreſſions étrangeres, il ne s'agit que de chercher ſi M. *Newton* avoit le Calcul des Fluxions ou infinitéſimal, avant vous, ou ſi vous l'avez eu avant lui. Vous l'avez publié le premier, il eſt vrai; mais vous avez avoué auſſi que M. *Newton* en avoit laiſſé entrevoir beaucoup dans les Lettres qu'il a écrites à M. *Oldenbourg* & aux autres. On prouve cela fort à long dans le *Commercium*, & dans ſon *Extrait*, Quelles ſon vos Réponſes? Voila ce qui manque encore au Public, pour juger exactement de l'affaire.

Vos amis attendent vôtre réponſe avec beaucoup d'impatience, & il leur ſemble que vous ne ſauriez vous deſpenſer de répondre, ſi non à M. *Keill*, du moins à M. *Newton* lui même, qui vous fait un deffi en termes exprès, comme vous verrez dans ſa Lettre.

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[a] In his Letter dated *Feb.* 26. 1715-16. *ſt. vet.* and Printed at the End of *Raphſon*'s Hiſtory of Fluxions.

[b] Printed in the *Philoſophical Tranſactions*, N. 342. and in Tome VII. *du Journal Literaire*.

[c] Dated 17. *March* 1693. and printed at the End of *Raphſon*'s Hiſtory of Fluxions.

[d] Entituled, *Analyſis per Series numero terminorum infinitas*.

Je

Je voudrois vous voir en bonne intelligence. Le public ne profite guere des diſputes, & il perd ſans reſſource, pour bien de ſiécles, toutes les lumieres que ces mêmes diſputes lui dérobent.

Sa Majeſté a voulu que je l'informaſſe de toute ce qui s'eſt paſſé entre M. *Newton* & vous. Je l'ai fait de mon mieux, & je voudrois que ce fut avec ſuccès pour l'un & pour l'autre.

Vôtre Problême a été reſolu fort aisément en peu de tems. Pluſieurs Geometres à *Londres* & à *Oxford* en ont donné la Solution. Elle eſt générale, car elle s'étend à toutes ſortes de Courbes, ſoit Geometriques, ſoit Méchaniques. Le Problême eſt un peu équivoquement propoſé: mais je croi que M. *de Moivre* ne ſe trompe pas, en diſant, qu'il faudroit fixer l'idée d'une ſuite de Courbes. Par exemple ſuppoſer qu'elles ayent la même Soûtangeante pour la même Abſciſſe; ce qui conviendra non ſeulement aux Sections Coniques, mais à une infinité d'autres tant Geometriques que Mechaniques. On pourroit encore faire d'autres ſuppoſitions pour fixer cette idée.

Je vous parlerai une autre fois de la Philoſophie de M. *Newton*. Il faut convenir auparavant de la Methode de philoſopher, & diſtinguer avec beaucoup de ſoin la Philoſophie de M. *Newton*, des conſequences que pluſieurs en tirent fort mal à propos. On attribuë à ce grand homme bien de choſes qu'il n'admet pas; comme il l'a fait voir à ces Meſſieurs Francois qui vinrent à Londres, l'occaſion de la grand Eclipſe.

Je ſuis avec tout le reſpect poſſible

A *Londres*, Monſieur, vôtre *&c.*
Mars 1716.

N. B. *Mr.* l'Abbé Conti *ſpent ſome Hours alſo in looking over the old Letters and Letter Books kept in the Archives of the* Royal Society, *to ſee if he could find any thing which made either for Mr.* Leibnitz, *or againſt Mr.* Newton, *and had been omitted in the* Commercium Epiſtolicum Collinii & aliorum: *but could find nothing of that kind.*

Monſieur, Hanover *ce* 14. d'Avril, 1716.

Mr. Leibnitz's *Anſwer.*

2.] Pour ne vous fair attendre, je vous dirai par advance que j'ai répondu d'abord à l'honneur de vôtre Lettre, & en même tems à celle que M. *Newton* vous a écrite; & j'ai envoyé le tout à M. *Remond* à *Paris*, qui ne manquera pas de vous le faire tenir. Je me ſuis ſervi de cette voie, pour avoir des temoins neutres & intelligens de nôtre Diſpute: & M. *Remond* en fera encore part à d'autres. Je lui ai envoyé en même tems une copie de vôtre Lettre & celle de M. *Newton*. Après cela vous pourrez juger, ſi la mauvaiſe chicane de quelques uns de vos nouveaux Amis m'embarraſſe beaucoup.

Quant au Problême dont quelques-uns parmi eux ont voulu reſoudre des cas particuliers, pour en fixer, diſſent-ils, les idées; il y a de l'apparence qu'ils ſe ſeront jettez ſur des cas faciles: car il y en a dans les Courbes Tranſcendantes, auſſi-bien que dans les ordinaires; mais il

s'agit d'une ſolution generale. Ce Problême n'eſt point nouveau. M. *Jean Bernouilli* l'a deja propoſé dans le mois de *May* des Actes de *Leipſic* 1697. *p.* 211. Et comme M. *Fatio* mépriſoit ce que nous avoins fait ; on en repeta la propoſition pour lui & pour ſes ſemblables, dans les Actes de *May* 1700. *p.* 204. Il peut ſervir encore aujourd'hui à faire connoitre à quelques-uns, s'ils ſont allez auſſi avant que nous en Methodes : & en attendant qu'ils trouvent le moyen de parvenir à la ſolution génerale, ils pourront eſſayer ce qu'ils péuvent, en fixant les idées ſur un cas particulier, qu'on leur propoſé dans le papier cy-joint. Sa ſolution vient encore du même M. *Bernoulli*. Ainſi vous aurez la bonté de ne pas vous rendre trop tôt aux inſinuations de ceux qui nous ſont contraires ; comme lorſqu'ils vous font a croire que nôtre Problême leur étoit aiſé. Je ſuis avec zele, Monſieur, vôtre *&c.*

Problema continens caſum ſpecialem Problematis generalis de invenienda Serie Curvarum, quarum quælibet ſit ad aliam Seriem Curvarum perpendicularis.

Fig. 34. *Super recta* A G *tanquam axe, ex puncto* A *conſtructis Curvis quotcunque qualis eſt* A B D, *ejus naturæ ut radius oſculi ex ſingulis ſingularum Curvarum punctis* B *eductus* B O *ſecetur ab axe* A G *in* C *in Data ſemper conſtanti ratione : ut nempe ſit* B O *ad* B C *ut* M *ad* N. *Conſtruendæ jam ſunt Trajectoriæ qualis eſt* E N F, *priores Curvas* A B D *ſecantes ad angulos rectos.*

Thus far this Letter.] Mr. *Leibnitz* firſt propoſed the general Pro-
Fig. 35. blem to M. *l'Abbé Conti* in theſe Words ; *Trouver une ligne* B C D, *qui coupe à angles droits toutes les courbes d'une ſuite determiné d'une même gendre ; par exemple, toutes les Hyperboles* A B, A C, A D, *qui ont le même ſommet & le même centre ; & cela par une voye generale.* And in the *Acta Eruditorum* for *October*, 1698. *p.* 470, 471. he calls the Curves in this determinate Series, *Curvas ordinatim datas, & poſitione datas, & poſitione ordinatim datas.* And by all this, the Series of Curves to be cut is given, and nothing more is to be found, than the other Series which is to cut it at right Angles. But Mr. *Leibnitz* being told that his Problem was ſolved, he changed it into a new one, of finding both the Series to be cut and the other Series which is to cut it. And the particular Problem propoſed in this Letter is a ſpecial Caſe, not of the general Problem firſt propoſed, as it ought to have been, but of this new double Problem. And the firſt Part of this double Problem, (*viz.* by any given Property of a Series of Curves to find the Curves) is a Problem harder than the former, and of which a general Solution is not yet given. Mr. *Leibnitz* in a Letter to Mr. *John Bernoulli*, dated 16. *December*, 1694. and publiſhed in the *Acta Eruditorum* for *October* 1698. *p.* 471. ſet down his Solution of the Pro-

blem, when the given Series of Curves is defined by a finite Equation, expreſſing the Relation between the Abſciſs and Ordinate. The ſame Solution holds when the Equation is a converging Series, or when the Property of the Curve to be cut, can be reduced to ſuch an Equation, by the *Analyſis per Series numero terminorum infinitas.* But Mr. *Leibnitz* was for ſolving the Problem without converging Series.

XXIII. In Epiſtolâ pro eminente Mathematico *Actis Lipſienſ.* 1716. Plagii accuſor, tanquam inventa *Bernoullii*, aliorum, uſurpaſſem ut mea. Exempla proferat, dabitur reſponſum. Plura ſanè tractavi cum aliis communia; ſed inventis alienis ſum minime uſus ut meis. Propria ubique ſum uſus Analyſi, (ſi Iſoperimetrum excipias, de quo poſtea dicetur;) ut nullo modo dici poſſit me alios fraudaſſe. At Autores nominaſſe oportebat, unde artem hauſeram. Tanta me quidem tenet reverentia illuſtrium nominum, Hugenii, Hoſpitalii, Varignonii, Leibnitii, aliorum, ut neſciam an ex hac parte non peccaverim, cum mihi ipſi deeſſe videar, qui tantos viros citaſſe ſemper fuiſſet ornamento. Nimia fortaſſe ignavia erat, quod de rebus cum eſſem maxime ſollicitus, hiſtorias rerum penitus neglexerim. Sperabam tamen me in tantæ fraudis ſuſpicionem incidere non potuiſſe, cum illuſtriſſima tantorum virorum opera eam facilè detegerent. Quæ cum Bernoullio communiter tractavi problemata, ſunt, de Funiculariâ, de Centro Oſcillationis, & de Iſoperimetris. In duobus primis ſum propria omnino uſus analyſi; in Iſoperimetro uſus ſum analyſi Autoris Jacobi Bernoullii, Viri à rebus Mathematicis optimè meriti, cui debitos nunc perſolvo honores. Solutio noſtra problematis de Centro Oſcillationis, cum amicis meis communicata eſt uſque ab initio Anni 1712. ut teſtes poſſum citare epiſtolas autographas Keillii noſtri; Liber item noſter erat penes Societatem Regiam, & cum omnibus fere noſtris Mathematicis communicatus, uſque à menſe Aprilis Anni 1714. quod hic monitu neceſſarium duxi, ne & Solutionem illam ſibi vindicet Bernoullius; cujus Solutiones [a] duæ extant eodem Anno editæ; quarum poſterior cum noſtra, quoad principia, tam mirè conſentit, ut jurares ab eodem homine eſſe utraſque inventas. Materia de Iſoperimetris excogitata primum eſt à Jacobo Bernoullio, ſicut jam innuimus. Ejus extat Solutio cum Analyſi, in Actis Lipſienſibus Anni 1701. Extat Analyſis fratris in Commentariis Regiæ Scientiarum Academiæ Anni 1706. Extat & Solutio in Libro noſtro. De eadem materia Commentarium nuper edidit Bernoullius in Actis Lipſienſibus Anni 1718. proximi [b] Ibi, ne actum agere videatur, non meis ſolummodo, verum etiam fraternis

Dr. Taylor's *Apology againſt* J. Bernoulli, n. 360. p. 955.

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[a] Altera in Act. Lipſ. M. Jun. In Comm. Reg. Sc. Acad. M. Aug. altera.

[b] P. 16. & ſeq. His igitur aliaſque ob rationes, actum agere minimè videbor, &c. *p.* 18.

ſolu-

ſolutionibus malevolus detrahere aggreditur ; fratri prolixitatem [c] mihi obſcuritatem [d] objiciens. De novis illis inceptis nihil non magnum [e] pollicetur ; & *ope cujuſdam principii, ab uniformitatis lege, quam nemo hucuſque obſervavit, petiti,* rem totam pene ſine calculo, nullo labore abſolvet. Sed neſcio quo fato fit, ut in hac materia de Iſoperimetris, Bernoullius Deos omnes ſemper offendat iratos. Nam primo, priſtina illa Analyſis ejus à capite ad calcem quaſi unum aliquod vitium maximum conſtituit. Secundo, quod tantum jactitat Principium, à lege uniformitatis, quam nemo hucuſque obſervavit (ſic enim ſtrenuus affirmat) petitum, à me olim obſervatum eſt: Denique quam hic tanquam novam exhibet Analyſin, tota mera fraterna eſt. Analyſin enim conſtituunt Præcepta, juxta quæ deinde inſtituitur calculus ; qui non Analyſis eſt, ſed inſtrumentum Analyſeos. Præceptis ſemel poſitis, quivis facilè calculum inſtituit, more quiſque ſuo, hic prolixius, ille magis concinnè, prout unicuique faverit Minerva. Negandum non eſt, Bernoullium calculum tandem concinnaſſe, & reddidiſſe elegantiorem ; ſed tamen in Analyſi fraterna fecit, non ſua: Nec dubitandum quin frater, adhuc ſi vixiſſet, rem reddidiſſet non minus illuſtrem. Analyſin diximus in præceptis contineri ; præcepta verò ſunt omnia fraterna. Nam quod curvæ quæſitæ arculum minimum, tanquam ex tribus lineolis elementaribus compoſitum contemplatur, vel ipſo fatente [f] à fratre eſt: quod ex data longitudine arculi iſtius minimi quærit rationem differentiarum Ordinatarum in Lemmatis ſuis, à fratre eſt: quod rationem eandem denuo quærit, faciendo ut ſit areola naſcens, ex Functionibus (ut vocat) compoſita, vel maxima vel minima, à fratre eſt: quod denique ex

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[c] Nullos hic offendet Lector *ſcopulos*, quos objicit *operoſa* Fratris analyſis, atque differentiarum tertiarum *tricas ac ſpinas*, quibus *undique obſeptam* ibi ſentit viam, in noſtra methodo nullas percipiet.——Nec fratris calculi prolixitatem, nec Taylori obſcuritatem æque ingratam ac moleſtam ſibi metuendam habeat, *p.* 18——quam Frater per *operoſiſſimam* ſuam analyſin elicuit, *p.* 23——non tantum ea, quæ à fratre meo quondam propoſita *magna pompa*, *nec minori conatu & labore* ſoluta fuere, ego ex ſola lege uniformitatis ſolvi citra calculum analyticum, &c.

[d] *Vide Not. præced.*——*item quæ ex* p. 18. *jam ſunt deſcripta.*

[e] ——Lætus confidam, *publicum ei gratiam habiturum*, quod occaſio mihi extiterit, talia nunc divulgandi, quæ fortè cum multis aliis in ſchedis meis perpetuò manſiſſent ſepulta, quamvis *reconditæ Geometriæ fines non parum prolatura*, p. 17. quod ibi ex incuria prætervisum reparabo hic *novo ſolvendi modo* qui ſingulari facilitate expedit problemata, non tantùm omnia quæ de Iſoperimetris propoſuerat Frater, ſed & innumera alia illis affinia, *ib.*——ope cujuſdam principii ab uniformitatis lege, *quam nemo hucuſque obſervavit*, petiti, ex ſola Figuræ inſpectione, ac fine ullo pene calculo æquationes pro curvis quæſitis ſponte velut ſe offerentes ſtatim eliciam, &c. ut in *Not. c.* actum agere minimè videbor ſi in hoc argumento per ſe difficili viam monſtrem & rationem *brevem, planam, claram, & facilem*, qua quiſque mediocri quoque ingenio præditus ad veritates illas abſtruſiores (non fide aliorum, ſed) propriis oculis ſpectandas pervenire poſſit, ita nempe, ut, &c. *ut in Not. c.*

[f] Utar pro hoc, ut ipſe fecit in ſua Analyſi, contemplatione arculi minimi, &c. *p.* 18.

duplici

duplici illa expreſſione ejuſdem iſtius rationis æquationem colligit qua curvæ quæſitæ natura definiatur, à fratre eſt. Sed hæc Solutionem conſtituunt. Ergo ſolutio mera fraterna eſt. Dixi me olim uſum eſſe Principio illo, quod tanta cum oſtentatione ſibi arrogat Bernoullius: Ex eadem una pagina, en duo exempla. In pagina 113. Libri mei hæc

" ſunt $\frac{m'}{R'} = \frac{m}{R}$ .. Sed eſt $\frac{m'}{R'}$, novus valor ipſius $\frac{m}{R}$, unde eſt $\frac{m}{R}$ quantitas

" data." Luce clarius eſt me hoc loci ex obſervata uniformitate inter formulas, $\frac{m'}{R'}$, $\frac{m}{R}$, concluſiſſe quod ſit $\frac{m}{R}$ quantitas data. Idem feci in ſequentibus. " Pone $\frac{m'n}{nR'} = \frac{m}{R}$, hoc eſt $\frac{m''n'n}{R'} = \frac{m'nn}{R}$, &c." ubi ut uniformitas appareret inter formulas $\frac{m''n'n}{R'}$, $\frac{m'nn}{R}$, æquationem tranſformavi. Videtis, credo, quàm feliciter penetraverim ad *profundiora* Bernoullii. An hæc obſcura dicet?

Ad primam jam partem promiſſi pervenio, ut oſtendam priſtinam illam Analyſin Bernoullii eſſe omnino corruptiſſimam. Primo per ſubſtitutionem ſatis ridiculam, ex *profundioribus ſuis* neſcio quibus petitam, æquationem $FO \times \Delta RO \; \phi\omega \times \Delta \varrho\omega$ transformat in hanc $FO \times \Delta PF = \phi\omega \times \Delta \pi\phi$; quod in caſu particulari (nempe quando functiones ſunt ut quadrata ordinatarum) huc redit, ut ſint ſimul $FO \times RO = \phi\omega \times \varrho\omega$ & $FO \times PF = \phi\omega \times \pi\phi$; unde confit $PF : RO :: \pi\phi : \varrho\omega$. Sed hoc impoſſibile eſt, quoniam eſt vel $PF \urcorner RO \urcorner \varrho\omega \urcorner \pi\phi$, vel $PF \llcorner RO \llcorner \varrho\omega \llcorner \pi\phi$; quorum neutrum cum analogia expoſita conciliari poteſt. Nam ſi $PF \urcorner RO \urcorner \varrho\omega \urcorner \pi\phi$, per Analogiam etiam erit $\pi\phi \urcorner \varrho\omega$, (propter $PF \urcorner RO$) contra hypotheſin; vel ſi $PF \llcorner RO \llcorner \varrho\omega \llcorner \pi\phi$, per Analogiam etiam erit $\varpi\phi \llcorner \varrho\omega$, contra hypotheſin. Secundo parum ſcienter fingit curvaturam in F eſſe ad curvaturam in ϕ ſicut eſt ϕO ad FO; cum nihil in hac tota Analyſi ſit quod privilegium illud vindicet puncto O potius, quam alio cuilibet puncto ω in arculo minimo $FO\,\omega\,\phi$ ubivis ſumpto. Nec ſanè Curvedo tam ridicule vult æſtimari. Ter-

tio nimis imperitè facit $mn = ddx$, $nl = ddy$, & $ml = \frac{dtddy}{dx}$, cum ſint $mn = \frac{1}{2}ddx$, $nl = \frac{1}{2}ddy$, & $ml = \frac{dtddy}{2dx}$. Denique quod omnium peſſimum eſt, vitioſiſſimis hiſce principiis perfectiſſimam alligavit concluſionem. In problemate primo dico; nam in ſecundo eſt talium parentum magis digna proles. Errores Bernoullii veteres & exoletos me expoſuiſſe putatis. Non ita eſt; ipſe enim hæc habet: " *Omnia dudum* " *ſepoſita accuratè rurſus excutiendo ad ſeveri examinis trutinam revocavi* [g]. " Notandum autem Solutionem *primi* problematis in ſchediaſmate meo " Commentariis Acad. *p.* 235. inſerto. *rectiſſimè ſe habere* [h]." Errores ergo ſuos jam denuo adoptavit. Unde fortaſſe nunc quæret aliquis, Quo jure hic primas ſibi in ſublimiori illa Analyſi tam obſtinata ambitione arroget? Ut nemo ſit qui in illa aliquid profecerit, quin continuo accuſetur *ad profundiora Bernoullii penetraſſe* [i]: Unde conſtet verum eſſe, quod quidam nuper affirmavit, regulas extantes in libro de Analyſi infinitè parvarum à Bernoullio emanaſſe [k]? Quod laudes Excellentiſſimi Marchionis Hoſpitalii ſint ſuo Præceptori tribuendæ? An hic ſit idoneus qui alios docuerit *regulas differentiandi differentias* [l]? Cum multis aliis quæ ſigillatim enumerare non eſt opus.

A Vindication of Mr. J. Gregory, *by Dr.* D. Gregory, n. 308. p. 2236. ★ Vid. ſupr. V. 1. C. 1. S. XXIX. 3.

XXIV. Duodecim abhinc annis ★ *Jacobi Gregorii* Cl. Viri, Patrui mei defenſionem ſuſcepi contra calumnias Abbatis *Galloyſii*, qui [m] & illum celeberrimum *Barovium* quaſi Propoſitiones ſuas de *Transformatione Curvarum* à *Robervallio* ſurripuerint, apud Orbem Literatum criminatus eſt. Quandoquidem vero eandem denuo litem redintegrat *Galloyſius* [n] liceat mihi ſuum Patruo meo Decus vindicare.

Septem annos poſt editum *Gregorii Librum* vixerat *Robervallius*. An vero ille, qui leviſſimam quamque gloriolam captavit, qui nihil ſibi non arrogavit, nihil cuiquam proprium eſſe voluit, has ſibi propoſitiones ſuas eripi vivens videnſque pateretur. At non viderat, inquit *Galloyſius*, per tot annos nihil legerat novum, & omnibus ſe inventis ſpoliari

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[g] Page 16. [h] Page 17. [i] Page 18. *vide etiam Ep. pro Em. Math. & ſcripta ipſius Bernoullii paſſim.*

[k] Concedit Dn. Marchionem de l'Hoſpital calculum iſtum intellexiſſe, nec ignorat, illuſtriſſimum hunc virum eundem à Cel. Bernoullio didiciſſe: atque minime ipſum fugit, regulas in dicto libro [*de Analyſi infinitè parvarum*] extantes à Cl. Bernoullio promanaſſe, *Act. Leipſ. An.* 1718. *p.* 464.

[l] Dum interea conjici poteſt, illum cum Dn. Newtono ab initio in iſto errore hæſiſſe, donec tandem liberati fuiſſent uſu *calculi differentialis, & regulas differentiandi differentias à Cel. Bernoullio edocti eſſent*, ib. p. 465.

[m] *Hiſt. Acad. Reg. Pariſ.* 1693. [n] *Hiſt. Acad. Reg. Pariſ.* 1703.

facile

facile paſſurus Famæ jam & Matheſi valedixerat. Miror quo ore hæc ſua proferat commenta, quæ tam facile coargui poſſunt. Tantum enim abeſt ut *Robervallius* ab anno 1668. in ſeceſſu & ab eruditorum commercio remotus degerit, ſtudiaque depoſuerit mathematica, ut in Academia *Pariſienſi* Matheſeôs Profeſſor Anno jam 1670. novæ Stateræ inventionem Academiæ Scientiarum Regiæ communicaret [a] uti Acta eo anno impreſſa teſtantur. Interfuit itaque *Robervallius* Academicorum conventibus, & ſi ipſe nihil tum legerit, nihilne tamen de his adeo in *Gallia* celebratis *Gregorii* inventis ad illius aures fando pervenit? Nihil horum accepit ab *Hugenio* [b] qui tum temporis contra *Gregorium* inter Academicos acerrimè diſputavit? Vel ſi nulla illi cum *Hugenio*, ut *Galloyſius* dicit, familiaritas interceſſerat (forte quia præcipuam & maxime utilem *ſuæ Trochoïdis* proprietatem ab *Hugenio* inventam fuiſſe dolebat) nihil a cæteris omnibus Academicis per univerſum ſeptennium audire potuit. Aut ſi audiſſet, nihilne queſtus eſſet, ne ipſis quidem Fratribus ſuis & Amicis? Tam fuiſſe eum Gloriæ abſtinentem haud temere quiſquam credet, qui illius cum Italis, cum Suis, cum omnibus rixas intellexerit. Quod ſi repente factus eſt tam patiens, tam famæ averſus *Robervallius*, ut ſua omnia aliis tribui facile permiſerit, quæque feliciter invenit, intra ſcrinia ſua latere, quam in lucem prodire maluerit; quî tandem factum eſt, ut hæc ab eo ſumere potuerit *Gregorius?* Videamus quibus argumentis fretus *Galloyſius* hanc criminationem denuo urgere pergat. [c] *Primo, inquit, methodum hanc de transformatione curvarum a* Robervallio *excogitatam in* Italia *ante annum* 1668. *notam eſſe conſtat, quia* Torricellius *qui mortuus eſt An.* 1647. *in Epiſtolis ſuis teſtatur eam ſibi a* Robervallio *communicatam eſſe.* 2^do *Hanc methodum cum* Gregoriana *eandem eſſe invitus fatetur adverſarius.* 3^tio *Itaque veriſimile admodum videri debet, quod* Gregorius *dum in Italia peregrinaretur, hanc methodum tam diu in* Italia *cognitam ab* Italis *habuerit.*

Quod Methodus hæc, quæ ſub *Robervallii* nomine prodiit An. 1692. eadem ſit cum illa quam Prop. XI. *Math. Univerſ.* jam ante annos viginti quatuor ediderat *Gregorius*, ſicuti utramque inſpicienti ſatis clarum eſt, ita a me ultro conceſſum fuit. Dixi quidem eam in Gallorum ſcriptis, ubi *Robervallio* tribuitur, demonſtratione miſerâ & pudendâ veſtitam, ſed non eandem eſſe cum *Gregoriana* nunquam diſputavi, nullam ex hac parte litem movi, utcunque in ea præcipuam inter nos quæſtionem verſari dicat *Galloyſius*, meque ſuper eâ manus dediſſe ſerio triumphet. Nondum tamen illi concedo eam vel Italis ante notam eſſe, vel ab iis *Gregorio* impertitam. Quomodo enim liquet iis fuiſſe notam? Quia eam *Robervallius* cum *Torricellio* communicavit. Unde vero hoc conſtat? Ex Epiſtola ipſius *Torricellii*. Ubi eſt hæc Epiſtola?

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[a] *Journals des Sçavans An.* 1670.
[b] *Journales des Sçavans An.* 1668.
[c] *Oeuvres des Mathem. par Meſſ. de l'Acad. Roy.*

Apud *Galloyſium*. Quando ſcripta eſt? Annis abhinc fere ſexaginta. Ubi tam diu latuit? Ubi omnia mirabilia latent, in ipſis *Robervallii* apothecis. An hæc Epiſtola genuina ſit, multo minus an omnino ſit, in tanta teſtimoniorum luce nefas eſt dubitare. Sed ex quibus literarum monumentis evincitur *Torricellium* hæc inventa Italis impertitum eſſe? De hoc altum eſt adhuc ſilentium. Vel ſi cui hæc forte impertiit, potterant, tamen iterum excidiſſe, & penitus fuiſſe ignota, cum ipſe *Torricellius* viginti jam annis ante *Gregorii* in Italiam adventum mortuus fuerit. Aut ſi nondum memoriâ hominum exciderant, dicat ſi poteſt *Galloyſius* quis Mathematicorum hæc arcana ſibi a *Torricellio* commiſſa *Gregorio* oſtenderit. Dicet fortaſſe (quid enim pro arbitrio ſuo non dicet) in Italia multis nota eſſe. An vero Itali Arcana hæc Geometrica quæ per viginti annos nuſquam prodiere, *Gregoria* demum peregino crederent? An ille in media *Italia* (Liber enim ejus *Patavij* impreſſus eſt) auſus eſſet pro ſuis venditare quæ modo ab Italis didicerat? Vel ſi fuiſſet adeo expers Verecundiæ, hoccine fieri potuit, ipſis non modo non reclamantibus ſed etiam plaudentibus Italis? Mihi quidem hoc non fit veriſimile.

XXV. *A Paper omitted.*

N. 338. p. 5. Logometria Auctore *Rogero Cotes*, Trin. Coll. Cantab. Soc. Aſtron. & Ph. Exp. Profeſſore *Plumiano*, & R. S. S.

XXVI. *Accounts of Books, &c. omitted.*

N. 292. p. 1699. 1. *Lexicon Technicum*, or an Univerſal Engliſh Dictionary of Arts and Sciences; explaining not only the Terms of Art, but the Arts themſelves, by *J. Harris*, M. A. and F. R. S. *Folio* 1704.

N. 289. p. 1558. 2. *Euclidis* quæ ſuperſunt omnia Gr. Lat. ex Recenſione *Davidis Gregorii* M. D. Aſtronomiæ Profeſſore *Saviliano*, & R. S. S. *Oxon.* 1703. *Folio.*

N. 354. p. 732. 3. *Apollonii Pergæi* Conicorum Libri Octo, & *Sereni Antiſſenſis* de Sectione Cylindri & Coni Libri duo. *Fol.* Reg. e Theatro *Oxon.* 1710.

The 5th, 6th, and 7th Books of *Apollonius* are here tranſlated out of *Arabic* from a MS. by Dr. *Halley*, in which Language they are only to be found; who has alſo endeavoured to reſtore the 8th Book which was wholly loſt. The *Greek* Text of *Serenus Antiſſenſis* was never publiſhed before.

N. 291. p. 1607. 4. De *Locis Solidis* Secunda Divinatio Geometrica, in Quinque Libros injuriâ Temporum amiſſos *Ariſtæi* Senioris Geometræ; Auctore *Vincentio Viviani*, Magni Ducis *Etruriæ* Mathematico Primario, & Regalis Societatis *Londini* Sodali. Opus *Conicum* in lucem prolatum, An. 1701. *Folio.*

N. 345. p. 339. 5. *Methodus Incrementorum* Auctore *Brook Taylor*, LL. D. & R. S. S.

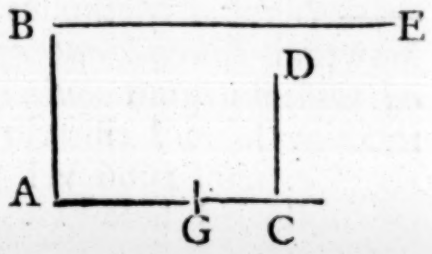
An *Error* in the 25th Propoſition of this Book is here corrected by Dr. *Taylor*.

This

This Error does not affect the Reaſoning by which I find the Diſtance of the Center of Percuſſion from the Axis of Rotation; but it is this, that I ſuppoſed the Center of Percuſſion to be in the Plane paſſing thro' the Center of Gravity, and perpendicular to the Axis of Rotation; which is a Miſtake, and is corrected by the following Propoſition.

PROP. PROB.] *To find the Diſtance of the Center of Percuſſion from the Plane paſſing through the Center of Gravity and perpendicular to the Axis of Rotation.*

SOLUTION.] Let this *Figure* be ſuppoſed in the Plane paſſing through the Axis of Rotation, and in which the Center of Percuſſion is ſought.



Let *AB* be the Axis of Rotation, *AGC* be the Interſection of this Figure with the Plane paſſing through the Center of Gravity, and perpendicular to the Axis of Rotation; *G* be the Point whereon a Line, rais'd perpendicular to this Figure, will paſs through the Center of Gravity; *B E* be a Line parallel to *AG*, wherein is the Center of *Percuſſion*. Then to find the Diſtance *AB*, let *p* ſtand for an Element of the Body propoſed, ſtanding perpendicularly on any Point *D*. Draw *DC* perpendicular to *A G C*, and *A B* will be equal to the Sum of all the Quantities $p \times GC \times CD$ taken with their proper Signs, divided by the Body itſelf multiplied into the Diſtance *A G*.

Having thus found the Diſtance *AB*, ſuppoſe the Plane of the Figure in *Prop.* 25. to cut the preſent Figure at Right-Angles in the Line *BE*, and the Center of Percuſſion will be rightly determined by that Propoſition.

6. *Commercium Epiſtolicum Collinii & aliorum de Analyſi promotâ.* Publiſhed by the *Order* of the *Royal Society*, in relation to the Diſpute between Mr. *Leibnitz* and Dr. *John Keill*, about the Right to the Invention of the Method of *Fluxions*, by ſome call'd the *Differential Method*. N. 342. p. 173. *Vid.* ſupra p. 162.

This Book conſiſts of Letters, and other Papers, which paſs'd many Years ago between Mr. *Collins*, Sir *Iſaac Newton*, Mr. *Leibnitz*, Dr. *Barrow*, Dr. *Wallis*, Mr. *Oldenburg*, Mr. *J. Gregory*; the Occaſion of their being publiſh'd was this:

The Editors of the *Acta Lipſienſia* for *January* 1705, (in giving an Account of Sir *Iſaac Newton*'s *Treatiſe of* Quadratures) *began* to repreſent that Mr. *Leibnitz* was the *Firſt* Inventor of the *Differential* Method, and that Sir *Iſaac Newton* had ſubſtituted *Fluxions* for *Differences*; Dr. *John Keill* upon this, in a Paper publiſh'd in the *Philoſophical Tranſactions* (for *September* and *October* 1708.*) aſſerted the Invention to

* *Vid.* infra C. IV. S. V.

to Sir *Iſaac Newton*, appealing to the Letters which Dr. *Wallis* had printed in the Collection of his Works, publiſh'd many Years ſince. Mr. *Leibnitz* upon this complain'd to the *Royal Society* of Dr. *Keill* in 1711; whereupon the *Society* appointed a numerous *Committee* of Gentlemen of *ſeveral Nations* to ſearch old Letters and Papers, and to report their Opinion, which was

That from theſe Papers it appears, that Sir *Iſaac Newton* had found the Method of *Fluxions* in or before the Year 1669.

That it does not appear from theſe Papers, that Mr. *Leibnitz* had the Method of *Fluxions* or *Differential* Method before the Year 1677.

Dr. *Wallis* (in the Second Volume of his Works publiſh'd) in 1695, aſſerted the Invention to Sir *Iſaac Newton* in theſe Words, —— *Newtoni* Methodus de Fluxionibus — *quam ego deſcripſi ex binis* Newtoni *Literis*, *aut earum alteris*, Junii 13, & Octob. 24. 1676. *ad* Oldenburgum *datis*, *cum* Leibnitio *tum communicandis* — *ubi* Methodum hanc Leibnitio exponit *tum* ante decem Annos *nedum plures* [i.e. ann. 1666 vel 1665.] *ab ipſo excogitatam* —— Several Letters followed hereupon, between Mr. *Leibnitz* and Dr. *Wallis*, in which Mr. *Leibnitz* did not deny that Sir *Iſaac Newton* had the Method *Ten Years* before thoſe *Two Letters*; pretended not that he had the Method ſo early; brought no Proof that he had it before the Year 1677; no other Proof beſides the Conceſſion of Sir *Iſaac* that he had it ſo early; affirmed not that he had it earlier; and commended Sir *Iſaac Newton* for his Candour in this Matter.

When Mr. *Fatio* in 1699 ſuggeſted that Mr. *Leibnitz*, the *Second* Inventor of this Calculus, might borrow ſomething from Sir *Iſaac Newton*, the *oldeſt* Inventor by many Years, Mr. *Leibnitz* in his Anſwer in the *Act. Erud.* for *May* 1700, allow'd that Sir *Iſaac* had found the Method apart, and did not deny, that Sir *Iſaac* was the oldeſt Inventor by many Years; and aſſerted then no more to himſelf, than that he alſo had found the Method apart, or without the Aſſiſtance of Sir *Iſaac*; nor did he put in his Claim to be the *Firſt* Inventor, till after the Death of Dr. *Wallis*, the laſt of the Old Men, who were acquainted with what had paſs'd between the *Engliſh* and Mr. *Leibnitz* Forty Years ago. The Doctor died in *October* 1703, and Mr. *Leibnitz* began not to put his *New* Claim before *January* 1705.

CHAP.

CHAP. II.
OPTICS.

I. *THE manner of ſeparating the primitive Colours of Light to ſuch a Degree, that if any one of the ſeparated Lights be taken apart, its Colour ſhall be found unchangeable, was not publiſhed before Sir* Iſaac Newton's *Optics came abroad. For want of knowing how this was to be done, ſome Gentlemen of the* Engliſh *College at* Liege, *and Monſieur* Mariotte *in* France, *and ſome others, took thoſe for primitive Colours, which were made by immitting a Beam of the Sun's Light into a dark Room through a ſmall round Hole, and refracting the Beam by a triangular Priſm of Glaſs placed at the Hole. And by trying the Experiment in this manner, they found that the Colours thus made were capable of Change, and thereupon reported that the Experiment did not ſucceed. And lately the Editor of the* Acta Eruditorum *for* October 1713. pag. 447. *deſired that Sir* Iſ. Newton *would remove this Difficulty.* Objectiones, *inquit*, quas Viri docti tum in Gallia tum in Anglia contra illam [de Coloribus] Theoriam fecere, feliciſſime diluit Vir perſpicaciſſimus *Newtonus*, quemadmodum ex Tranſactionibus Anglicanis N. 84, 85, 88, 96, 97, 121, 123, 128 abunde conſtat. Unde multi optant ut mentem ſuam aperire dignetur, de difficultate ab ingenioſiſſimo *Mariotto*, rerum naturalium (dum viveret) ſcrutatore indefeſſo nec infelici, in Tractatu de Coloribus *p.* 207, & ſeq. contra eam motâ. In diſtantia ſcilicet 25 circiter aut 30 pedum, charta excepit radium ſolidum per exiguum foramen in cameram obſcuram immiſſum, & per Priſma vitreum trigonum tranſmiſſum, coloremque violaceum ſpatium majus quam trium linearum occupantem per crenam duarum linearum trajectum, alio Priſmate excepit admodum obliquè oppoſito: quo facto quandam ejus partem in Rubrum & Flavum tranſmutari obſervavit. Similiter luminis rubri partem in cœruleum & violaceum tranſmutari expertus eſt. Hac verò tranſmutatione admiſſa corruere Theoriam Newtoniam, ex Actis A. 1706. p. 60, & ſeq. manifeſtum eſt. Aſſumpſit autem *Mariottus* diſtantiam 30 pedum, ne quis exciperit in minori diſtantia nondum factam eſſe plenariam radiorum heterogeneorum ſeparationem. Nobis experimentum *Mariotti* tum demum videretur deciſivum, ſi lumen cœruleum integrum in aliud mutatum fuiſſet. *Thus far the Editor of the* Acta. *In anſwer to which it is to be obſerved, that the Red and Yellow which came out of the Violet, and the Blue and Violet which came out of the Red, might proceed from the very bright Light of the Sky next encompaſſing the Sun, and that ſeveral ſorts of Rays which come from ſeveral Parts of the Sun's*

Some of Sir Iſaac Newton's *Experiments of Light, and Colours repeated, by Mr.* J. T. Deſaguliers. N. 348. p. 433.

Vid. ſupra. V. I. C. III.

Body are intermixt in all Parts of the coloured Spectrum *which falls upon a Paper at any Diſtance from the Priſm. In this manner of Trial, for making the Experiment ſucceed, the Light of the bright Clouds, immediately ſurrounding the Sun, ſhould be intercepted by an opake Skreen plac'd in the open Air without, at the Diſtance of ten or twenty Foot from the Hole through which the Sun ſhines into the dark Room. And in the Skreen there ſhould be a ſmall Hole for the Sun to ſhine through. The Hole may be either round or oblong, and not above one eighth or one tenth Part of an Inch broad; ſo that the Skreen may intercept not only the bright Light of the Clouds next encompaſſing the Sun's Body, but alſo the greateſt Part of the Sun's Light: For thereby the Colours will become leſs mixed. The Beam of Light which paſſes through this Hole muſt afterwards paſs through the other Hole into the dark Room, and the Priſm muſt be placed parallel to the oblong Hole in the Skreen, and the refracting Angle thereof be ſixty Degrees or above. In this manner the Experiment may be tried with Succeſs, but the Trial will be leſs troubleſome if it be made in ſuch a manner as is deſcribed in the fourth Propoſition of the firſt Book of Sir* Iſaac Newton's *Opticks.*

Sir Iſaac Newton *therefore, upon reading what has been cited out of the* Acta Eruditorum, *deſired Mr.* Deſaguliers *to try the Experiment in the manner deſcribed in the ſaid Propoſition; and he tried it accordingly with Succeſs before ſeveral Gentlemen of the* Royal Society, *and afterwards before Monſieur* Monmort *and others of the* Royal Academy *of* Sciences: *How this and other concomitant Experiments were tried and ſucceeded, is deſcribed as follows.*

Experiment 1.] Having ſew'd together end-wiſe two Pieces of Ribbon four Inches long each, the one blue and the other red, whoſe common Breadth was $\frac{1}{4}$ of an Inch; I caus'd it to be held in ſuch manner, that the Light which fell from the Clouds thro' the Window was ſo reflected, that the Angle made by the Rays of Light, which came in at the Middle of the Window, with the Plane of the Ribbon produced, was equal to the Angle made by a Line drawn from the Ribbon to my Eye, and the ſaid Plane of the Ribbon. My Eye was plac'd as far behind the Ribbon as the Window was before it, the Diſtance from which to me was about 12 Feet. Then looking thro' a Priſm at the Ribbon, it appeared broken aſunder in the Place where the blue and red Half join'd. If the Priſm was held with the refracting Angle downwards (or laid with one of its Planes flat upon the Noſe) the blue Half of the Ribbon appear'd to be carried down lower than
Fig. 36. the red, as at *B*, *R*; but if the refracting Angle of the Priſm was turn'd upwards (as when the Priſm has one of its Planes laid flat to the Forehead) then the blue Half of the Ribbon was lifted up, as at $b\varrho$.

The Priſm was of white Glaſs, having every Angle of 60 Degrees; but when inſtead of it, one of a greeniſh Sort of Glaſs, ſuch as Object Glaſſes of Teleſcopes are made of, was uſed, having the refracting Angle which I look'd thro' of about 48 Degrees; the ſame Phæno-

menon was more diſtinct, this Glaſs having no Veins, but the red and blue were nearer to a ſtreight Line: In ſuch manner that if *A* repreſent the Ribbon ſeen through the firſt Priſm, *B* will repreſent the Ribbon ſeen through the ſecond Priſm, *Fig.* 37. If the refracting Angle of the laſt Priſm had been as great as that of the firſt, the Light being tranſmitted through too great a Body of greeniſh Glaſs, the Phænomenon would not have ſucceeded ſo well. Fig. 37.

The blue Ribbon being ſomewhat too pale, and the red a little dull; I repeated the Experiment with a Skain of blue, and one of red Worſted join'd together in the Middle as the Ribbons were before; and the Colours of both being very intenſe, the Experiment ſucceeded better with both Priſms. All that were preſent trying the Experiment found it to ſucceed, and that every Circumſtance anſwer'd to the Account given in *Prop.* 1. *Theor.* 1. *Book* 1. of Sir *Iſaac Newton*'s *Optics*, as far as the Directions there given were followed. So that it appeared that the blue being carried lower than the red in the firſt Caſe, and lifted higher in the ſecond, was owing to the greater Refraction of the blue Ray: For though each Part of the Ribbon or Worſted reflected all manner of Rays, yet the Phænomenon was very apparent; as alſo that the blue Ribbon or Worſted reflected the blue Rays more copiouſly than the red Rays, and that the red Ribbon or Worſted reflected the red Rays more than the blue ones, becauſe the red of the blue Half ſeen through the Priſm was leſs intenſe than that of the red Half, and the blue or Purple of the red Half ſeen through the Priſm was leſs intenſe than that of the blue Half.

N. B. If the Ribbon or Worſted is laid upon any enlightened Body, the Phænomenon will not ſucceed ſo well; the Colours of the Body ſeen through the Priſm mixing with thoſe of the Ribbon or Worſted. Even a black Body will not do, if Light fall upon it: But there muſt be a black Cloth behind, in ſuch manner that no Light falling upon it can be reflected ſo as to diſturb the Phænomenon. And if a ſhort-ſighted Perſon looks through the Priſm, a concave-Lens between his Eye and the Priſm, will render the Phænomenon more diſtinct than it would otherwiſe be.

Exp. 2.] Some Days after the Sun ſhining, I made two Holes *H*, *h*, in the Window Shut *S*, *s*, of a darkned Room; through which letting the Sun's Beams paſs, by means of two Priſms *A*, *B*, (one near each Hole) I opened the Rays coming from the Sun into the two coloured *Spectra* α, β, where the following Colours were very diſtinct, *viz.* red, orange, yellow, green, blue, purple and violet. Now the Reaſon of their being more diſtinct than ordinary, was, that the Priſms which I made uſe of, were made of the greeniſh Glaſs mentioned before; which is very free from thoſe Veins by which the Colours are too much thrown into one another, by the beſt white Priſms of the common Sort. Fig. 38.

The

The forementioned coloured *Spectra* being thrown into the Room, to the Diſtance of about 20 Feet from the Window where the Sun's Light came in, I cauſed a Piece of white Paper π, $\frac{1}{4}$ Inch broad and 5 Inches long, to be held within the refracted Rays, (at a Diſtance of 10 Feet from the Window) which produced theſe Colours in ſuch manner, that by turning the Priſms round their Axis, I could make the red Ray of the *Spectrum* made by the one Priſm, fall upon one half of the Paper, and the purple Ray of the *Spectrum* made by the other Priſm fall upon the other half; for the *Spectra* were both vertical, the Lines which terminated the long Sides of them towards each other juſt touching, as appears in *Fig.* 38. Then at the Diſtance of 9 Foot, looking through the Priſm *C* at the Paper thus coloured, the red Half appeared very much ſeparated from the purple, the one ſeeming lifted up from the other; the red or purple appearing the higheſt, according as the refracting Angle of the Priſm was either held upwards or downwards. The Phænomenon is much more diſtinct this Way than any other; for the Paper not only ſeems divided into two, when it is coloured by a red and a purple Ray, but alſo by a red and blue, *Fig.* 39. by a red and a green Ray, *Fig* 40. or indeed by any two Colours that are different, how near ſoever their Places in the *Spectra* be to each other. The Halves of the Paper appear, when viewed through the Priſm, to be farther from each other, when the Paper is tinged with ſuch Colours, as are farther from each other in the Series of Colours in the *Spectrum*; and neareſt, though ſtill divided, when neighbouring Colours fall upon the Paper, as yellow and green, or a light and a deep green. But the Paper appears no way divided, when coloured with the red of the two *Spectra*, *Fig.* 41. if thoſe reds are equally intenſe; and ſo of the other Colours.

Fig. 38. Fig. 39. Fig. 40. Fig. 41.

Exp. 3.] I held a Lens of about 3 Foot Radius, at the Diſtance of ſix Feet from the oblong Paper (on which a red and a purple Ray falling, made it look half red and half purple) and I projected the Image of the ſaid coloured Paper at the Diſtance of about ſix Foot on the other Side of the Lens, on a white Sheet of Paper; where it was obſervable, that when the red Half was diſtinctly painted on the white Paper (which was known by the Edges of the Image being regularly terminated) then the blue Half of the Image was confus'd: But if the white Paper was brought about two Inches nearer to the Lens, the Image of the blue Half became diſtinct, and that of the red Half confus'd.

I tried the Experiment with a Paper coloured half red and half blue, the red with Carmine, and the blue with Smalt, making the Candle to enlighten the Paper (the Room being otherwiſe dark) and the Experiment ſucceeded in the ſame manner. The Experiment thus made, is the ſame that Sir *Iſaac Newton* gives an Account of, *Book* 1. *Part* 1. *Theor.* 1. *of his Optics.* Only it is to be obſerved, that when the oblong Paper is coloured with red and blue from the Priſms, the focal Place, where the red Part of the Image is diſtinct, is more diſtant from the Place

Place where the blue Part of the Image is diſtinct, than when the Paper is coloured with the Painter's Powders, and much more vivid.

The 42d Figure ſhews the Projection of the Paper ting'd with the Rays: and *Fig.* 43. the Projection of it when painted: where a black Thread is wrapp'd round the red and the blue Part, that the Diſtinctneſs of the Image of the Thread may ſhew when the red or when the blue Part of the Image of the Paper is moſt diſtinct. Fig. 42. Fig. 43.

N. B. When the Candle enlightens the painted Paper, ſet an opaque Body as *B* between the Candle and the Lens; leſt the Image of the Candle being alſo projected ſhould diſturb the Experiment.

Exp. 4.] Having made an Hole of $\frac{1}{4}$ Inch Diameter in the Window-Shut of the darkened Room, I ſuffer'd a Sun-Beam to come into the Room, which I intercepted with a Priſm at the Diſtance of 5 Inches from the Hole: and after its Refraction in paſſing through the Priſm, I receiv'd it upon a Sheet of white Paper, where it was coloured, making an oblong Image of the Sun or *Spectrum* of about 9 Inches in Length and 2 in Breadth, which Breadth was nearly equal to the Diameter of the round Image of the Sun received upon a Paper at the ſame Diſtance from the Hole, which here was 18 Foot. Or if the Sun be too high, a Looking-Glaſs being put in the Room of the Priſm, will throw a white round *Spectrum* upon the Paper, which held at the ſaid Diſtance of 18 Foot, will have its Diameter equal to the Breadth of the colour'd *Spectrum*.

The Colours of the *Spectrum* were theſe; red, orange, yellow, green, blue, purple and violet, though the Violet was ſo faint in this as to be ſcarce perceivable. See *Fig.* 44. Fig. 44.

N. B. The Axis of the Priſm in this, and all the other Experiments hereafter mentioned muſt be perpendicular to the Ray that falls on it; and the Plane into which the Ray enters muſt be held in ſuch a Poſition, that the Angle which ſuch a Ray makes with that Plane when it enters, may be equal to the Angle made by the middle Line of thoſe Rays which emerge after Refraction, on the other Side of the refracting Angle of the Priſm, with the Plane out of which they emerge. That is $\angle BDG = \angle AEH$.

If the Plane *AC*, on which the Sun-Beam falls, be turned nearer to a perpendicular to the Sun-Beam than before, the *Spectrum* will be much longer: If it be more inclined to the ſaid Beam, the *Spectrum* will be ſhorter, and in both Caſes leſs diſtinct. See the *Spectrum DE* and the *Spectrum de* where *Hh* repreſents the Hole in the Window-ſhut in each Caſe; *AC*, *ac* the Plane of the Priſm on which the Rays enter; *BC*, *bc* that out of which they emerge; *P*, *p* the perpendicular, and *C*, *c* the refracting Angle. Fig. 45, 46.

If the Plane *AC* be ſtill more oblique to *HF*, all the Light will be reflected, and there will be no coloured Image or *Spectrum* made by Refraction at all. Fig. 47.

But if it be held ſo as to be more nearly perpendicular to the Sun-

Beam than in *Fig.* 47. the whole Beam will indeed enter the Priſm; but meeting with *B C* the lower Surface of the Priſm, or rather the Surface of the Air contiguous to it, ſome of the Light will by the Plane *B C* be reflected to *d e*, paſſing almoſt perpendicularly through *A B*; and the reſt will emerge through *B C*, and by Refraction make the imperfect *Spectrum D E*. See *Figure* 45.

Fig. 45.

If the Sun-Beam enter *A C* perpendicularly and in the middle of it the Light will be all reflected as in *Fig.* 48. ſome of it by the Plane *B C* to *R*, and the reſt by the Plane *A B* to ρ. But if the Beam fall nearer to *A* (ſtill perpendicularly) it will be all reflected by the Plane *A B*; if nearer to *B*, it will be all reflected by the Plane *B C*.

Fig. 48.

In order therefore to have the coloured *Spectrum* as it ought to be, care muſt be taken that the emerging coloured Light may make the ſame Angle with the Plane *B C*, as the immerging Light does with the Plane *A C*; that is, the Angle *A E H* muſt be equal to *B D G*, as was ſaid before, *Fig.* 44. which may alſo be ſeen on the enlightened Duſt in the Air. But the beſt way is to turn the Priſm on its Axis, and at the ſame time look at the coloured *Spectrum*, which will riſe and fall and become longer and ſhorter as you turn your Priſm; and between the Aſcent and Deſcent of the Image, will appear ſtationary; there ſtop the Priſm, and the Reflection will be ſuch as is required for all the Experiments hereafter mention'd.

Fig. 44.

In order to have the Priſm move freely on its Axis, and ſtop any where, I fix'd each End of it into a triangular Collar of Tin, from the End of which came a Wire, which was the Axis of the Priſm produced; and ſo I laid it on two wooden Pillars, with a Notch on the Top to receive the Wires, and fixed it to a ſmall Board juſt broad enough to ſtand faſt. See *Fig.* 49.

Fig. 49.

Exp. 5.] I took the Priſm *C D*, and thro' it looked at the coloured *Spectrum R P*, which appeared then round and white as at *S*, juſt as if it had been the Sun's Light received on a Paper from the Hole *H*, and ſeen with the naked Eye. In this Caſe the Priſm *C D* muſt be held *in directum* with *A B*, and the refracting Angles in the two Priſms muſt be equal. This *Spectrum* appearing white but juſt in one Point, is not ſo readily found; but the beſt way is to look through the ſame Priſm *A B* which makes the *Spectrum*, which may eaſily be done if it be pretty long, and then *R P* will be ſeen white and round, and as at *S*, as if coming directly from *H*. See *Figure* 50.

Fig. 50.

Exp. 6.] I held a broad *Lens L l*, ground to a Radius of 2 ½ Feet, in ſuch manner that the whole coloured *Spectrum* fell upon it; and after Refraction all the Colours appeared to converge, if received on a Paper at *p p*; but when the Paper was held in the Focus at *F* in the Poſition *π F π*, the *Spectrum* was round and perfectly white by the Union of all the coloured Rays. If the Paper was held at Π Π, the Colours appeared to diverge from each other, but then the red was uppermoſt, which before uſed to be the loweſt, and ſo on in an inverted Order.

Fig. 51.

I tried the ſame Experiment with a *Lens* of one Foot Radius, with one of 9 Inches, and with another of 7, and the Succeſs was the ſame. See *Fig.* 51. where the *RO*, *Y*, *G*, *B*, *B*, *P*, *V*, expreſs the Colours. Fig. 51.

N. B. Care muſt be taken that the very End of the red, and the Extremity of the violet be taken in by the *Lens*; otherwiſe the *Spectrum* will not be perfectly white with the Glaſs's Focus.

There is no fixed Diſtance of the Priſm from the Lens, but it ought to be brought ſo near the Priſm, that the two Ends of the *Spectrum* may fall nearer the Axis of the Lens than the Edges of the Lens; becauſe there the Refraction is not ſo regular.

Behind the Lens *L*, which made the Colours converge into white at the diſtinct Baſe or Focus *F*, I placed the Lens *l*, which made the white be at *f* the diſtinct Baſe of the two Glaſſes combined; and the Experiment ſucceeded as before. *Fig.* 52. Fig. 52.

When the Paper was held in the Focus of the Lens, ſo as to receive the white Image of the coloured *Spectrum* projected by the Lens; if with a Card I intercepted the red Ray, the white appeared tinged with purple, and if I intercepted the violet or purple Ray, or both, the white appeared tinged with red; and if the red was intercepted at the ſame time, the *Spectrum* appeared to be a Mixture of yellow, green and blue. If any ſingle Colour was ſuffered to fall upon the Lens, the reſt being intercepted, that Colour would continue the ſame; only it would be more intenſe in the Focus of the Lens.

Exp. 7.] I took a Board (*Fig.* 53.) *q h s* which ſtood reclining on a Prop *t*, having an Hole of a quarter of an Inch Diameter at *h*, and behind it a Priſm *B* ſupported on two Props, as abovementioned, ſo as to turn eaſily about its Axis; and having ſet this Board on the Ground with the Priſm behind it at *B*; by turning the Priſm *AC* about its Axis, I firſt made the red Ray of the coloured *Spectrum* paſs though the Hole *h*, and fall obliquely upon the ſecond Priſm *B*. This Ray after its Refraction in paſſing through the ſecond Priſm, was carried up to the Ceiling of the Room at the Place marked *R*: then I made the purple Ray fall upon the Board, and paſs through the Hole *h*, as the red had done before; and after Refraction through the Priſm *B* it was carried up the Ceiling at *P*. And the green Ray being afterwards made to paſs the ſecond Priſm in the ſame manner, went up to *G*: And ſo of all the intermediate Rays, which were by this ſecond Refraction thrown to the intermediate places on the Ceiling between *R* and *P*. Fig. 53.

Care is to be taken that the ſecond Priſm be placed oblique to the Rays which come through the Hole *h*, leſt they be reflected, as they would be, if the Board being in the Poſition *QS*, and the ſecond Priſm in the Poſition *LNM*, the Ray from the firſt Priſm be *ρ h*; for then it will be reflected upwards to *σ* inſtead of being refracted, *Fig.* 54. Neither muſt the Plane of Immerſion be too oblique, leſt the Incident Ray be reflected downwards by it, as the Ray *R h* is by the Priſm *B* thrown to *E*, in *Fig.* 55. Several have confeſſed to me that they at Fig. 54. Fig. 55.

firſt uſed to fail in this Experiment, for want of ſetting the ſecond Priſm in a due Inclination.

Though the Colours by the ſecond Refraction on the Ceiling appeared unchanged, when ſeen by the naked Eye, yet if viewed through a Priſm, they afforded new Colours (except ſome part of the red, and ſome part of the violet) which was owing to their not being fully ſeparated; for which reaſon I made the following Experiment, to prove that if the Colours be well ſeparated, they are truly homogeneal and unchangeable.

N. B. When the Priſms are good, and no Clouds are near the Sun, the Extremity of the red or violet will afford unmixed Colours in this Experiment; otherwiſe not

Exp. 8.] Having made a Hole in the Window-Shut 2 Inches wide, Fig. 56. I applied to it a Tin-plate, which ſliding up and down hid all this Hole in the Wood, and only tranſmitted a ſmall Beam through its own Hole *H*, whoſe Diameter was $= \frac{1}{16}$ Inch. This Beam, by means of the Looking-Glaſs *L*, placed on the Board of the Window *XW*, I reflected horizontally to the other End of the Room. But to correct the Irregularity of the Reflection of the Looking-Glaſs, I made uſe of the Frame of Paſte-board *P p*, which had an Hole in it *h* of $\frac{1}{16}$ Inch likewiſe; and placing it at *P p* I ſuffered ſome of the reflected Beams to paſs through it, ſo as to fall upon the Lens *F E* (convex on both Sides, and ground to a Radius of $4\frac{1}{2}$ Feet) at the Diſtance of 9 Feet, ſo that the Image of the Hole *h* was projected to *f* on the other Side of the Glaſs, at the Diſtance of 9 Feet more. Juſt behind the Lens, which by a Screw in the Stand *S* might be raiſed or ſet down, ſo as always to receive the Beam along its Axis, I placed a Priſm *A* (upright on one of its Ends and eaſily moveable about its Axis, by reaſon of its Wire turning freely in an Hole in the ſolid Piece of Wood *T*, which ſtood on another Stand behind the Lens) as near as I could to the Lens *E F*, ſo that the Image of *h* inſtead of being round, white, and projected to *f*, was caſt ſidewiſe on a white Paper ſtretched on a Frame, and appeared coloured, and 30 or 40 times its Breadth, as at *M N*. The Colours in this Caſe were very vivid and well ſeparated, only the Violet had ſome pale Light darting from its End, upon account of ſome Veins in the Priſm *A*, and the Light not coming directly from the Sun, reflected; which ought not to have been, if the Sun had been low enough to have thrown the Rays a good way into the Room without the Help of a Looking-Glaſs.

To ſhew that the Colours in this *Spectrum* were ſimple and homogeneal Lights, I made the following Experiments.

Exp. 9.] Having made an Hole *h* in the Paper which received the coloured *Spectrum*, I ſuffered the red Light to paſs; which being refracted by a ſecond Priſm, fell upon another Paper at *T*, where it Fig. 57. appeared ſtill red whether ſeen with the naked Eye or Priſms of different refracting

refracting Angles. To the Eye which ſaw it through the Priſm *V*, it appeared indeed lower as at *t*, but red, round and unchang'd. I made the Experiment upon all the Colours, which by this means appeared to be ſimple and homogeneal. See *Fig.* 57. Where the ſame Letters denote the Lens, Priſm and firſt Paper. Fig. 57.

Through the ſame Lens and Priſm the *Spectrum* was made to fall on a Book; then through the Priſm *F* it appeared unchanged; and the Letters in the Book which croſs'd the *Spectrum* were as diſtinct as when ſeen with the naked Eye. See *Fig.* 58. Fig. 58.

N. B. The Axis of the Priſm *F* ought to be perpendicular to the long Axis of the *Spectrum s m* thrown on the Book, which will appear as at $\sigma\ \mu$; and the Priſm in the Poſition repreſented at *F*, with its flat Side towards the Noſe: For that is the moſt convenient Poſition for looking at the *Spectrum* in theſe Experiments.

I ſuffer'd the purple Ray only to paſs through the Hole *h* and fall upon a Book at *P*, the Letters of which appeared at π, and were as diſtinct through the Priſm ♌ as when ſeen with the naked Eye: and I had the ſame Succeſs with all the other Rays. See *Fig.* 59. Fig. 59.

But if a Sun-Beam as *r* comes through the Hole *H* directly upon the Book at *W*, an Eye looking at it through a Priſm at *X* will ſee this Beam at Υ oblong and coloured, and the Letters on which it falls, confuſed. See *Fig.* 59.

N. B. The Lens ought to be very good, without Veins or Blebs, and ground to no leſs a Radius than I mention'd in the Experiment; though a Radius of a Foot or two longer is not amiſs. The Priſm ought to be of the ſame Glaſs as the Object-Glaſſes of Teleſcopes, the white Glaſs, of which Priſms are uſually made, being commonly full of Veins. And the Room in theſe laſt Experiments ought to be very dark.

A few Days after, having got very good Priſms made for the Purpoſe of the abovementioned Glaſs, I made all the Experiments over again, before ſeveral Members of the *Royal-Society* with better Succeſs; and had the *Spectrum* very regularly terminated, without any pale Light darting from the Ends of it.

For a further Account of Experiments to this Purpoſe, See Sir Iſaac Newton's Optics, *Book* 1. *Part* 1. to which I might have referr'd the Reader altogether; but that I was willing to be particular in mentioning ſuch things as ought to be avoided in making the Experiments abovementioned; ſome Gentlemen abroad having complained that they had not found the Experiments anſwer, for want of ſufficient Directions in Sir *Iſaac Newton*'s *Opticks*; though I had no other Directions than what I found there.

An Experiment *to confirm the Doctrine of* Refrangibility, *by the* ſame, n. 348. p. 448.

II. After the *Experimentum Crucis* made by two Priſms, I ſhould not give the following Experiment, but that it is ſo eaſy to be made, that by it thoſe who want the *Apparatus* (or are unwilling to be at the Pains

Pains) to make the *Experimentum Crucis*, may at any time ſatisfy themſelves of the Truth of the forementioned Doctrine.

Let the Candle *A* be ſet before the Bar of a Chimney Looking-Glaſs
Fig. 60. ſuch as is repreſented by *HH Fig.* 60. which is a Piece of Looking-Glaſs Plate conſiſting of four Planes, ſeen in the Section of it $\alpha f d \beta$, *viz.* $d\beta$ which is quick-ſilver'd behind, $f\alpha$ a Plane parallel to it, fd one of the Side-planes bezzell'd towards $d\beta$, or inclined to it in an Angle of about 40 Degrees (though from 30 to 40 will do, but the greater the Angle the better, if it does not exceed 45°.) $\alpha\beta$ the other Side-plane inclined in the ſame Angle to βd.

The Rays of the Candle which come from *A* to γ fall obliquely on the Plane $\alpha\beta$, ſo that inſtead of going on to *a*, they are by Refraction made to incline more towards the perpendicular *p p*, namely, to go on in the Line γc, and then are reflected from the Point *c* on the quick-ſilver'd Surface, in the Direction $c\varkappa$, ſo as to make the Angle $\varkappa c d = \gamma c \beta$. Now as the Rays which would go to $\varkappa$, if not refracted, emerge obliquely from the Plane $\alpha\beta$ they leave the Direction $c\varkappa$, and decline from the Perpendicular $\pi\pi$, and, being differently refracted, open into four differently coloured Rays; *viz.* *b R* a red Ray, *b Y O* a Ray made up of orange and yellow; *b G B* a Ray made up of green and blue or a Sea-green, and *b P* a purple Ray.

If from the Place *E e* you look full upon the Point *b*, the *Spectrum* or Image of the Candle at *b* will appear double; but not mixed; that is, there will appear a Sea-green Spot, and a red Spot, as it were, one upon another, but not ſo as to produce a mixed or intermediate Colour. Then if the right Eye or Eye at *E* be ſhut, there will appear only a green Spot to the Eye at *e*; if the Eye at *e* be ſhut, the Eye at *E* will ſee only a red Spot.

If you come nearer to *b*, ſo that the Eyes at ε 1, ε 2 receive the moſt and the leaſt refrangible Rays, there will be a double *Spectrum*, *viz.* a red and a purple one juſt touching, or upon one another: And the Phæ-
Fig. 60. nomenon will anſwer as before, *Fig.* 60.

If keeping both Eyes open, you direct their Axes towards *O* a Point
Fig. 61. nearer than the uſual Place of the compound *Spectrum S*, *Fig.* 61. which Point is in a Line from the Noſe *N* to the Point *S*; or in other Words, if you look full at *O*, or at the End of your Finger held in *O*, the red and the blue (or purple Spot) will appear to be divided from each other
Fig. 62. after the manner repreſented at *p r* in *Fig.* 62. where the red will appear to be on the Right-hand, and the blue on the Left.

To make plain what is meant by *ſeeing* the *Spectra p* and *r* whilſt we look full at *O*, I beg leave to explain the Diſtinction between *looking* and *ſeeing*; that I may the better ſhew how this Phænomenon proves that the Senſation of different Colours is cauſed by Rays differently refracted.

Definition 1.] The *Optic Axis* is a Line which going through the Center of the Convexity of all the Coats and Humours of the Eye, falls upon
Fig. 63. the middle of the *Retina*, as αa or *A a*, Fig. 63.

Def.

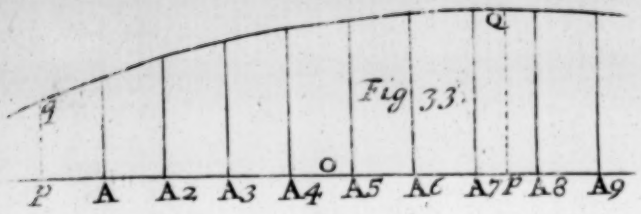


Fig. 33.

Fig. 34.

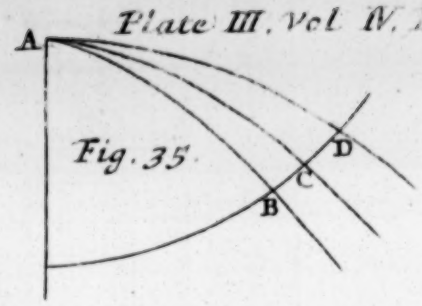


Fig. 35.

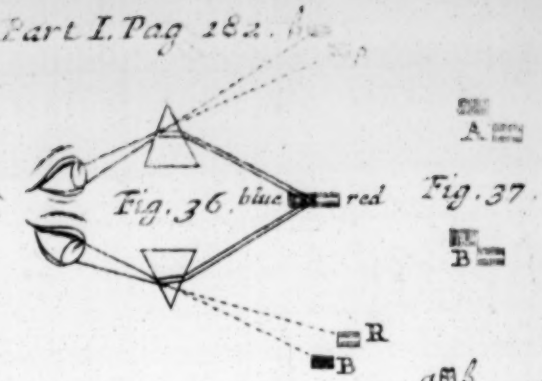


Fig. 36.

Fig. 37.

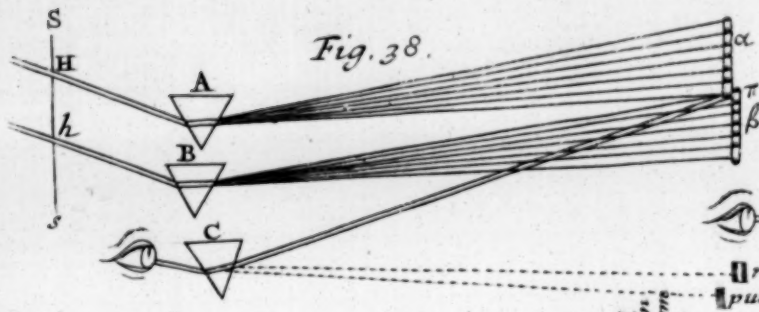


Fig. 38.

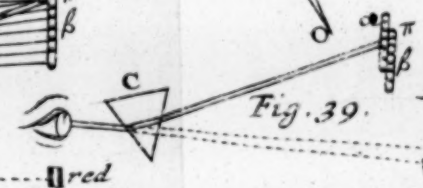


Fig. 39.

Fig. 40.

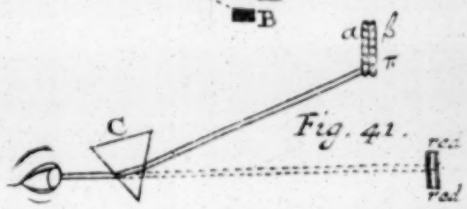


Fig. 41.

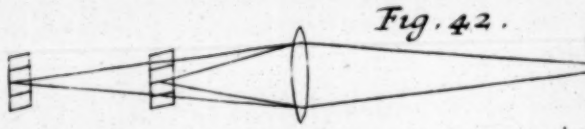


Fig. 42.

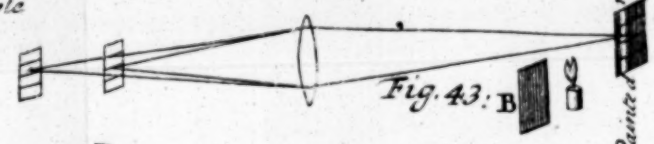


Fig. 43.

Fig. 44.

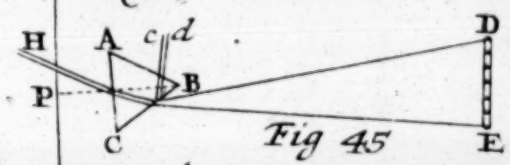


Fig 45

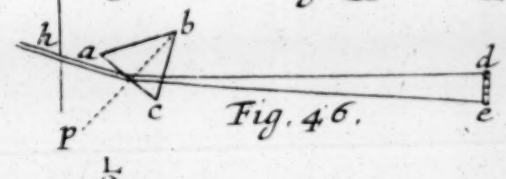


Fig. 46.

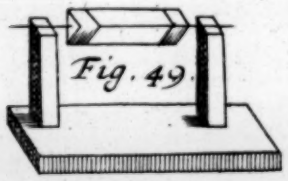


Fig. 49.

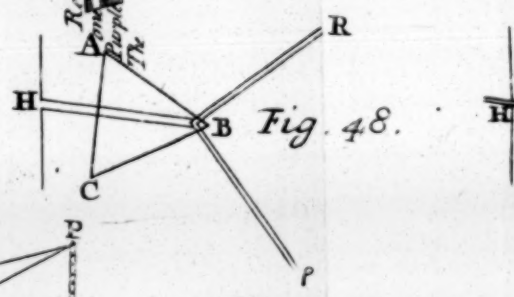


Fig. 48.

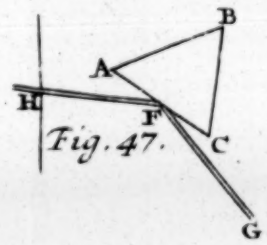


Fig. 47.

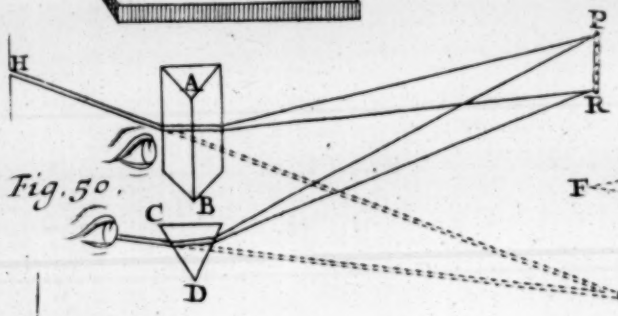


Fig. 50.

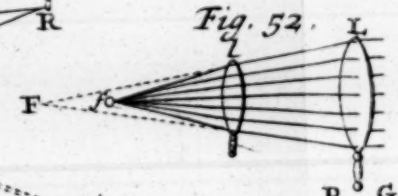


Fig. 52.

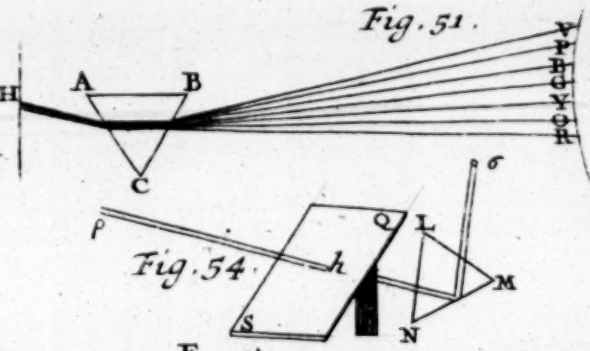
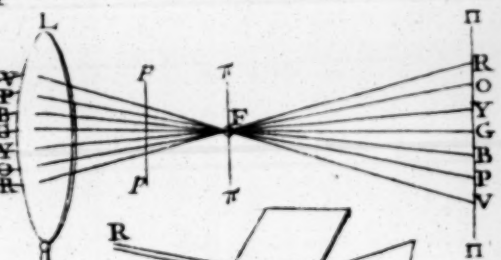


Fig. 51.



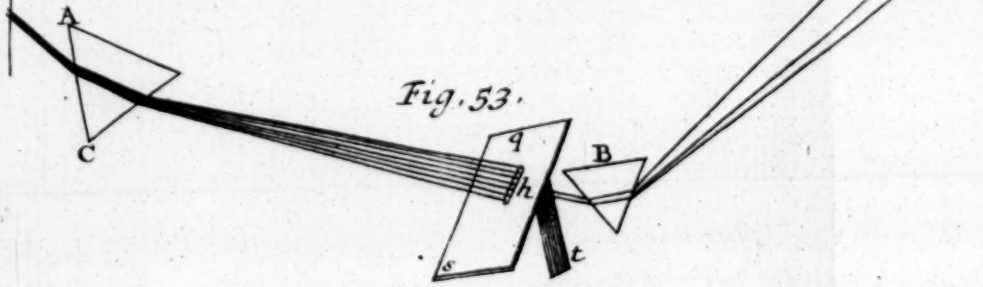


Fig. 53.

Fig. 54.

Fig. 55.

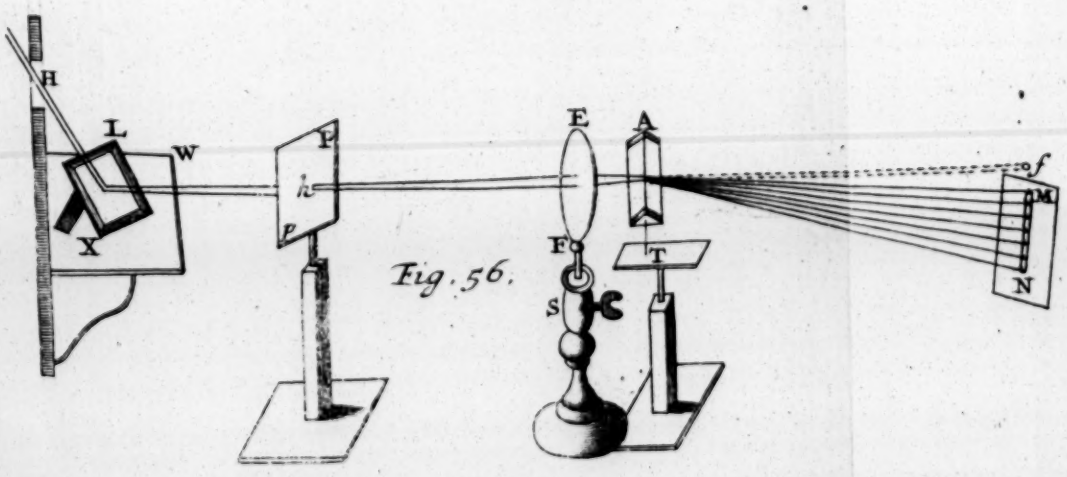


Fig. 56.

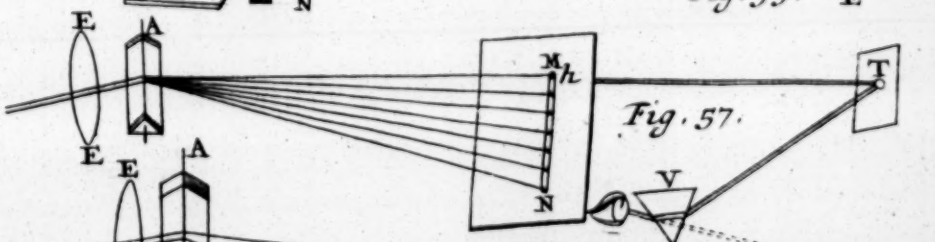


Fig. 57.

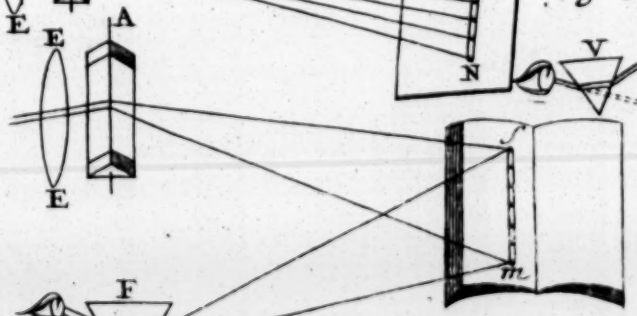


Fig. 58.

Def. 2.] To *look* at any Point, is to turn both Eyes towards it in ſuch manner, that the *Optic Axes* making an Angle at the ſaid Point as *a*, the Rays from *a* may have the *Optic Axis* for their Axis, and (by their Convergence upon the *Retina* after Refraction in the *Eye*) may paint the Image of the ſaid Point upon the middle of the *Retina* of each Eye, where the Optic Axis in each Eye falls.

Def. 3.] To *ſee* without *looking*, is to direct the Optic Axis to ſome other Place than to the Point which is then ſeen; and in ſuch a Caſe, the Image of the Point ſeen will be projected upon a Part of the *Retina* of each Eye, where the Optic Axis does not fall, namely either nearer to the Noſe *N*, as in *Fig.* 61. at the Points of the *Retina* mark'd *n n*; Fig. 61. or farther from the Noſe than the middle of the *Retina*, as at *o o* in *Fig.* 64. Fig. 64.

Whatever is *ſeen*, by being *look'd* at with both Eyes, always appears ſingle, by reaſon of the Communication between the middle of the *Retina* in one Eye, and the middle of the *Retina* of the other; there being no ſuch Communication between any other part of the *Retina* in one Eye, and the correſpondent Part of the *Retina* in the other, when theſe correſpondent Parts are equally diſtant from the Noſe.

There is indeed a Communication between the nervous Fibres on the Right-ſide of the Retina *of one Eye, and the nervous Fibres on the Right-ſide of the* Retina *of the other Eye, and ſo of thoſe on the Left; but no ſingle Object can be ſo painted in each Eye, as to have its Image on the right or left Part of one* Retina *that communicates with the right or left Part of the other, of the ſame Bigneſs and at the ſame Time as in the other; becauſe in whatever Poſition the Object is, it muſt be nearer to one Eye than to the other, except it be juſt in a Line from the Noſe betwixt the two Eyes ſtreight forward.*

Hence it is that if there be two Candles ſet before any one, the firſt at the Diſtance of one Foot, and the ſecond at the Diſtance of two Feet, from the Eyes; he that looks at the ſecond Candle at *B* will ſee it ſingle, but ſee the firſt Candle, or the Candle *A* double; one Appearance being in the Line *A D γ*, the other in *o A E*, becauſe it paints itſelf upon *o o* in the *Retina* of each Eye, which Points are not the middle Points, but farther from the Noſe than the middles *m m*.

So if *B* be the firſt Candle, and *C* the ſecond, he that looks at *B* will ſee *C* double, becauſe it is painted in the *Retina* at the Points *n n* nearer the Noſe than *m m*; and ſo will appear to be in the ſame Poſition as *p r*, in *Fig.* 62. Fig. 62.

If *γ ρ* be two Candles ſo diſpoſed, that by the Interpoſition of a perforated Board *F F*, *γ* can paint itſelf only in the Eye *R*, and *ρ* in the Eye *L*. Upon making the Optic Axes meet at *B* and to tend towards *ρ* and *γ*, *ρ* and *γ* will each paint an Image on the middle of the *Retina* of each Eye, by croſſing their Rays at *B*: And thus the two Candles will appear to be but one, or rather to be in one Place, upon the Account of the Communication of the middle of each *Retina*. But if inſtead of the Candles, *ρ* be a Piece of red Silk, and *γ* a Piece of green Fig. 65.

green Silk, the ſame Poſition of the Eyes will make an Image at *B*, appearing like a red and green Spot together without a Mixture of the Colours. If ρ be a red hot Iron, and γ a Candle of Sulphur, the Phænomenon will be more diſtinct. If the Optic Axes be turned directly towards γ and ρ, as if there was no Board *F F* in the way, there will appear two Holes in the Board, the one having the red hot Iron in it, the other the Candle.

Fig. 60. Now if, of the refracted Rays of the Candle in the firſt Caſe, thoſe which diverge from each other, ſo as to fall into each Eye, cauſe the ſame Senſations reſpectively, as the Rays which come from a red hot Iron and thoſe which come from a blue Candle; it is evident that the Candle in the firſt Caſe affords red-making and blue-making Rays

Fig. 60. after Refraction, and that thoſe Rays are differently refrangible; the red *b R* the leaſt refrangible, as declining leſs from the Perpendicular ϖ ϖ; and the purple as *b P* declining moſt from the ſaid Perpendicular.

The ſame will *(cæteris paribus)* be found true in the intermediate Rays, and to be certain that the Experiment is as I have related it, the Planes α *f* and *f d* of the Bar may be covered with Paper.

An Univerſal Spherico-Catoptric Theorem, by Mr. H. Ditton, n. 295. p. 1810.

III. Focorum Inventio tum in Dioptricâ, tum in Catoptricâ, ex Calculo pro curvis Cauſticis facili modo ſequitur. Nil enim alium agendum eſt, quam ut locus in quo Radius (ad Curvam, vel Refringentem, vel Reflectentem perpendicularis) Curvam Diacauſticam vel Catacauſticam tangit, cognitus habeatur. De quâ methodo videatur D. *Hayes* Liber Fluxionum nuper editus: nos ex aliis principiis, rem (ad Catoptricam quatenus ſpectat) aggrediemur.

Fig. 66. Sit *D E F* Speculi Sphærici concavi portio, cujus Centrum *B*, ſemidiameter *B E* vel *B D*: Sit etiam *A* punctum radians in axe collocatum, a quo profluat radioſa linea *A D*, quæ ad punctum *D* reflectatur in *D C*. Inveſtiganda jam eſt Foci *C*, a ſpeculi vertice *E* diſtantia.

Notandum vero, quod punctum *D* ipſi *E* proximum ſupponimus. Radii enim remotiores oculum (quem in axe *A E* conſtituimus) præterlabuntur, nec ad imaginis viſionem aliquid faciunt. Porro, propter arcum *D E* indefinite parvum anguli *D A B*, *A D B* (ut & ipſorum ſumma *D B C*) ſunt quam minimi, ac idcirco eandem habebunt inter ſe rationem, quam ipſis latera oppoſita: quo ratiocinii principio poſito, ad Theorema Dioptricum pervenit, D. *Halleius* Geometriæ Profeſſor apud Oxonienſes.

Hiſce præmiſſis, ſit $AB=b$. $BD=BE=r$. $BC=z$. $CE(=r-z$, ſed brevitatis cauſa ponatur$)=f$. Quantitates b & r cognitæ ſunt (dantur enim ſemidiameter ſpeculi, ac puncti lucidi a vertice diſtantia) z vero & f quæſitæ ac incognitæ. Jam in Triangulo *D A B*, erit $<DAB : <ADB :: r : b$. Item in Triangulo *D B C*, $<BDC = <ADB$, ex naturâ Reflexionis, & $<DBC=<DAB+<ADB$, ex Elem. Eucl. Ergo cum $<DBC$ ſit ut $r+b$, & $<BDC$ ut b; erit etiam

etiam $< DBC : < BDC :: r + b : b$, & (quod ex principio ſupra memorato conſequitur) $DC : BC :: r + b : b$. Sed quoniam punctum D ipſi E proximum eſt, erit DC ipſi CE æqualis eſtimanda, ergo $CE : BC :: r + b : b$; hoc eſt $f : z :: r + b : b$, & (comparando Antecedentium & Conſequentium ſummas ad Antecedentes) $f + z : f :: r + 2b : r + b$; ſed $f + z = r$, ergo $r : f :: r + 2b : r + b$, ergo $f = \frac{rr \times rb}{r \times rb}$.

Q: E: I.

Si ponatur $r + b\ (= AE) = d$, Theorema in formam contractiorem redigetur, & ſic ſtabit $f = \frac{rd}{2d - r}$. Sed utrovis modo focorum inventioni, quæcunque tandem ſit, vel Speculi forma, vel radiorum conditio, aptum evadet.

Coroll. I. Erit $zd = df - rf$, ſive $AE \times BC = AB \times CE$, vel quod idem eſt, linea AE harmonicè dividitur in punctis A, B, C, E; nam prædicta Rectangulorum æqualitas, lineæ ſecundum proportionem harmonicam ſectæ, propria eſt. Patet hæc veritas: Eſt enim $f = \frac{dr}{2d - r}$, & $z = r - f = r - \frac{dr}{2d - r}$, unde valores hoſce ſubſtituendo, Æquatio manifeſta fiet. Adeo ut in omni Speculo ſphærico, lineæ DA, DB, DC, DE, ſunt harmonicales; & Punctum radians, Centrum, Focus, Vertex ſunt puncta diviſionem harmonicam efficientia.

Coroll. II. 1mo Poſito $d > r$; erit ex calculo f, ſive $\frac{rd}{2d - r} > \frac{r}{2}$ ſemper. Hoc eſt, ſi puncti radiantis diſtantia major ſit Semidiametro Speculi, Foci diſtantia ſemper major erit quarta parte Diametri.

Item, erit $\frac{rd}{2d - r} < r$ ſemper. Hoc eſt, diſtantia Foci ſemper erit minor Speculi Semidiametro.

2do Si ponatur $d = r$, erit $\frac{rd}{2d - r}$, ſive $f = r$. Hoc eſt, ſi punctum radians in centro Speculi conſtituatur, Imago ejus ibi cum eo unietur.

3o Si ponatur $d < r$, tum ipſius f expreſſio erit vel poſitiva vel negativa vel infinita, prout quantitas $2d$ quantitate r vel major eſt vel minor, vel ei æqualis.

Si $2d > r$, hoc eſt, ſi $d > \frac{r}{2}$, tum punctum radians & focus ad eaſdem partes Speculi jacent.

Si $2d<r$, $d<\frac{r}{2}$, tum Imago, in axe ultra ſpeculi verticem producto, ſita eſt.

Si $2d=r$, vel $d=\frac{r}{2}$, Imago infinitè diſtat, ſive radius reflexus, axi parallelus evadit.

Coroll. III. Calculi hujus ope expedite determinari poteſt, quomodo objecti radiantis (ſpeculi reſpectu) motui, ipſius Imaginis motus reſpondet. Sit (ut antea) Imaginis a ſpeculo diſtantia $=\frac{dr}{2d-r}$, quando objecti diſtantia eſt d. Mutetur jam utcunque objecti diſtantia, & ex d, fiat nd, quantitate n Numerum vel integrum vel fractum deſignante: & ſic loco prioris Æquationis, $f=\frac{dr}{2d-r}$, habebimus pro Novo Foco aliam Æquationem, $F=\frac{ndr}{2nd-r}$. Et quidem ſi n Numerum integrum exprimere ſupponatur, ſecunda hæc objecti diſtantia primâ major erit, ſi vero ſit fractus, tum minor erit primâ.

Hiſce poſitis, ſi $d>r$, & n ſit integer, erit $F<f$, id eſt erit $\frac{ndr}{2nd-r}<\frac{dr}{2d-r}$, ſive $2nddr-ndrr<2nddr-drr$, quod manifeſtum eſt. Hoc eſt, ſi in ſpeculo concavo objecti diſtantia major ſit ſemidiametro, tum recedente objecto a ſpeculo, Imago verſus ſpeculum accedet. Rurſus, deſignet n Numerum fractum, & tunc reperietur $2nddr-ndrr>2nddr-drr$, ſive $F>f$. Hoc eſt, accedente objecto ad ſpeculum recedet Imago.

Supponatur jam $d<\frac{r}{2}$; ut & alia quæcunque ſit objecti diſtantia nd intelligatur ea ſemper minor eſſe quam $\frac{r}{2}$. Tum erunt $2nddr-ndrr$, & $2nddr-drr$, quantitates negativæ; ſive $ndrr-2nddr$, & $drr-2nddr$ quantitates poſitivæ. Et quidem ſi n numero integro æquetur, erit $ndrr-2nddr>drr-2nddr$, ſive $F>f$; ſi vero n fractio ſit, tum erit $ndrr-2nddr<drr-2nddr$, ſive $F<f$. Hoc eſt, ſi in ſpeculo concavo objecti diſtantia minor ſit ſpeculi Diametri quartâ parte, tum recedente objecto a ſpeculo, recedet & Imago; vel accedente objecto verſus ſpeculum, Imago etiam accedet.

Et hæc omnia (quæ calculi veſtigia premendo deduximus) Scholio unico concluſit, & in ſuâ Catoptricâ tradidit D. *Gregorius* apud Oxonienſes Aſtronomiæ Profeſſor.

Coroll. IV. In Æquatione $f = \frac{dr}{2d-r}$, ſi ponatur d infinita, erit $f = \frac{r}{2}$; quæ regula eſt pro Radiis parallelis, ſive pro objecto radiante ad diſtantiam infinitam remoto. Idem ſequetur, poſito b infinito in Æquatione $f = \frac{rr+rb}{r+2b}$.

Coroll. V. In Æquatione $\frac{dr}{2d-r}$, mutato quantitatis r ſigno negativo in poſitivum, erit $f = \frac{dr}{2d+r}$; vel in Æquatione $f = \frac{rr+br}{r+2b}$, mutato ſigno poſitivo in negativum, erit tunc $f = \frac{rb-rr}{2b-r}$, quæ regulam exhibet pro ſpeculo verſus objectum radians *convexo*. Patet hæc mutatio ſigni; nam ſicut in ſpeculo concavo $d = r+b$, ſic in convexo $d = b-r$.

Coroll. VI. In ſpeculo convexo (ſtantibus quæ ad Cor. III. annotavimus de Concavo) patebit quod (ſi n ſit numerus integer) $2rndd+ndrr > 2rndd+drr$; & (n fractione exiſtente) quod $2rndd+ndrr < 2rndd+drr$. Hoc eſt, quod recedente objecto a ſpeculo, vel verſus idem accedente Imago ſimiliter recedet vel accedet.

Patet etiam in ſpeculo convexo, objecto ad immenſam uſque diſtantiam retrocedente, Imaginem tamen illius non ultra Diametri partem quartam abire a vertice, ſed ibi, in puncto, centrum inter & verticem medio, ſe ſiſtere. Poſito enim d vel b infinito; erit $f = \frac{dr}{2d}$ vel $\frac{br}{2b}$, id eſt (utrovis modo) $= \frac{r}{2}$.

Hiſce adjungi poteſt & Problematis Catoptrici ſolutio, *Radiantis poſitionem reſpectu ſpeculi dati talem invenire, ut radians ad ipſius Imaginem a ſpeculo factam, datam habeat rationem.* Sit Ratio data $r : q$ & ſymbolo O deſignetur Objectum, I Imago, d diſtantia objecti, & f imaginis a ſpeculo. Jam (quod demonſtravit D. *Greg.*) erit $O : I :: d : f$, (hoc eſt Objectum & Imago ſunt diſtantiis ſuis a ſpeculi vertice directè proportionales) & quoniam requiritur ut ſit $O : I :: r : q$. debet etiam eſſe $d : f :: r : q$, vel (ipſius f expreſſionem ſcribendo) $d : \frac{dr}{2d-r} :: r : q$, unde $2ddq - rdq = rdr$, & $2dq = rr + qr$, & $d = \frac{rr+rq}{2q}$. Unde quoniam $dr = \frac{rrr+rrq}{2q}$, & $2d-r = \frac{rr}{q}$, erit etiam

f ſive $\frac{dr}{2d-r} = \frac{rrr+rrq}{2q} - : \frac{rr}{q} = \frac{qrrr+qqrr}{2qrr} = \frac{r+q}{2}$, quæ eſt ipſius f ſive Imaginis a ſpeculo diſtantia, huic objecti diſtantiæ congrua. Ergo ſi ſtatuatur objectum ad diſtantiam $\frac{rr \times rq}{2q}$, ipſius Imago facta ad diſtantiam $\frac{r+q}{2}$ ei comparata, eandem habebit rationem, quam $q : r$, ſive erit $O : I :: r : q$. Nam $O : I :: d : f :: \frac{rr+rq}{2q} : \frac{r+q}{2} :: r : q$. *Q. E. I.*

Objectum Radians & Imaginem hic tanquam lineas conſideravimus. Si enim Superficies ſunt, tum erit $O : I :: d^2 : f^2$, & $d^2 : f^2 :: r : q$, ſic ut ultimo deveniatur ad Æquationem $4dd - 4qdr = r^3 - qrr$, e quâ radicis d valor, Methodis vulgaribus facillimè inveniri poteſt.

A way for Myopes *to uſe* Teleſcopes *without Eye-Glaſſes*, &c. *communicated by Dr.* J. T. Deſaguliers, n. 361. p. 1017.

IV. *Myopes* may uſe *Teleſcopes* without Eye-Glaſſes, an Object-Glaſs alone becoming as uſeful to them, and ſometimes more than a Combination of Glaſſes.

Lemma 1.] What is requir'd of a Teleſcope is to give large, and diſtinct Viſion; that is, to make the Object (as in *Galilæo*'s Teleſcope) or its Image (as in the Teleſcopes made up of convex *Lentes*) appear under a great Angle, and to have all the Rays of thoſe Pencils that enter the Eye, meet in a Point upon the *Retina* of the Eye, on their reſpective Axes.

Fig. 67. The 67th Figure repreſents the Combination of two convex *Lentes* for the aſtronomical or inverting Teleſcope; where the abovementioned Requiſites are obtain'd. AB is the Object ſuppoſed at a vaſt Diſtance from the objective *Lens* LL, ſo that Rays coming from the Extremity A of the Object, will fall upon the *Lens* LL, in the ſame manner as if they were parallel to their Axis AX; and after paſſing the Glaſs unite at a, where they project the Image of the Point A; from whence diverging, they fall on the Eye-Glaſs ll, and having paſſed through it, go on parallel to each other, and enter the *Cornea* of a common Eye E, which unites thoſe parallel Rays upon its *Retina* RRR at α, where the Image of a is projected: The ſame may be ſaid of the Rays that come from B, and after their ſeveral Refractions through the two Glaſſes and the Coats and Humours of the Eye, meet upon the *Retina* at β, where they project the diſtinct Image of the Point b. The Rays that come from all the Points of the Object AB being affected after the ſame Manner, give a diſtinct Image of thoſe Points upon the *Retina*, and therefore the Object does appear diſtinct.

The

The Object will alſo appear magnified in the ſame Proportion as the Angle $l C l$ = to $b M a$ (under which its Image is ſeen) is greater than the Angle $A C B$ under which the Object $A B$ would be ſeen by the naked Eye; as is more at large demonſtrated by dioptrical Writers.

Lemma 2.] If parallel Rays fall upon the *Cornea* of a *Myops*, or ſhort-ſighted Perſon, they will unite in the Eye before they come to the *Retina*, the farther from it the more convex the Eye is; but if the Rays which fall upon the *Cornea*, diverge in proportion to the too great Convexity of the Eye, as from *D*, ſuch Rays will be ſo refracted by the Coats and Humours of the Eye, as to meet in one Point upon the *Retina R R*, where I have in the Scheme neglected the Refraction of the Rays paſſing out of the *chryſtalline K* into the *vitreous* Humour V, as I do in the other Caſes. Fig. 68, 69.

This *Lemma* is alſo demonſtrated by dioptrical Writers.

Lemma 3.] If two Pencils of Rays (in each whereof all the Rays are parallel to the Axis, as *a C*) fall upon different Parts of the *Cornea*, at the greateſt Diſtance from one another that can be allow'd for thoſe Rays to enter the Pupil *P P*, their *Axes* will, after entring the *aqueous* Humour, converge, and meet either in the vitreous or chryſtalline Humour, according to the Convexity of the *Cornea* through which they paſs'd, and diverge again before they come to the *Retina*; the Rays of each Pencil converging upon their reſpective Axes, to the Place where the ſaid Axes croſs one another. Fig. 70.

Demonſtration.] The Axes $a C a$, $\alpha C \alpha$, falling obliquely upon the *Cornea* at *C C*, and entring from *Air* into the *aqueous* Humour, will be refracted towards the Perpendicular to *K*, where ſtriking more directly upon the *chryſtalline*, they will go on to α, a, upon the *Retina R R R R*, decuſſating at *V* within the *vitreous* Humour. The other Rays r, r; ϱ, ϱ, after their Refraction in the *aqueous* Humour, fall more obliquely on the *chryſtalline*, and therefore are refracted again ſo as to meet at *V*, where the Axes alſo meet, and thence go on to the *Retina R R R R*. Fig. 70.

Lemma 4.] But if the Axes of the abovemention'd Pencils are parallel, the Rays that accompany them diverging from a Point ſo near the Eye, that the Divergence may be proportionable to the too great Convexity of the Eye; then only the Axes will meet in the Eye before they come to the *Retina* (by *Lemma* 3.) but the other Rays will not unite upon their reſpective Axes, till they come to the *Retina*, (by *Lemma* 2.)

Prop.] I ſuppoſe the Eye of the *Myops* ſo convex that he can ſee no farther than a common Eye, with the Eye-Glaſs of a Teleſcope before it: Then the Eye of the *Myops* being in the Place of the Eye-Glaſs, will receive the Rays diverging from the ſeveral Points of the Image (projected by the Object-Glaſs in its *Focus*,) in ſuch manner, that they will after the ſeveral Refractions meet in reſpective Points on the *Retina*; and the Axes of the Pencils which come from the Extremities of the Object, will, in the Eye, make the Angle

B V A = to *b c a*, under which the Image *a b* is ſeen, by *Lemma* 4. The *Cornea* and *Aqueous* Humours here ſupply the Place of the Eye-Glaſs, and the *Chryſtalline* and *Vitreous* Humours that of a common Eye. In the Figure *R* is the *Retina*, *V* the *Vitreous* Humour, and *K K* the *Chryſtalline* Humour; and the Image *b a* is ſuppoſed to be brought down from the 67th *Figure* which repreſents the *Aſtronomick Teleſcope:* the too great Convexity of the Eye here being in the Place of an Eye-Glaſs.

Fig. 71.

An Objection may be made to this, *viz.* that *P P* the Pupil of the Eye being ſmall, will take in but a very little Image, or a ſmall Part of the Object: But then if the Eye be moved ſucceſſively, to all the Parts of the Space where the Eye-Glaſs was, it can take any Part of the Object; and if the Object-Glaſs be large, which may more eaſily be made than a large Eye-Glaſs, and the Tube a Foot wide or wider, as much may ſucceſſively be taken in, as if an Eye-Glaſs might be had of a Foot Diameter. A little Practice may make any *Myops* ſo ready, as to keep an Object when once found, though the Place where he ſtands be ſhaken. It would not be amiſs to hold a *Lens* in one's Hand (for an Eye-Glaſs) to find the Object at firſt, till Cuſtom has made it eaſy without it: When once the Object is found, it may be eaſily kept.

An Eye more ſhort-ſighted than I have ſuppoſed, will perform the Office of a more Convex Eye-Glaſs, being brought nearer to the diſtinct Baſe of the Object-Glaſs; and an Eye leſs Convex, the Office of a leſs Convex Eye-Glaſs: But with this Difference, that the more Convex the Eye is, the eaſier may any Part of the Object be found, and the larger and more lucid it will appear.

I have ſeen *Saturn*'s Ring very plain with an Object-Glaſs of little more than ſix Foot *Radius*, without an Eye-Glaſs.

I have alſo found out a way for the *Preſbytæ* to make uſe of an Object-Glaſs, by placing their Eye nearer the *Lens* than its *Focus*, by ſo much as their Eye is flatter than a common Eye, ſo as to make (as it were) the Teleſcope of *Galilæo*; the flat Eye ſerving as a common Eye armed with a Concave *Lens*. I have ſo fiexd the Teleſcope, as to make a *Preſbyta* read at a great Diſtance a ſmall Print. The Truth of this may be eaſily demonſtrated, if it be required.

If this Experiment be made at Sea with a very large Tube, big enough to put in the Head and move it about, and the Object-Glaſs be alſo large, it may not perhaps be difficult to obſerve the Eclipſes of the *Satellites* of *Jupiter*, which I would recommend to the Conſideration of thoſe that would try for the Longitude by ſuch like Obſervations.

Experiments upon Metals, with the D. of Orleans's *Burning-glaſs by Mr.* Geoffroy, n. 322. p. 374.

V. The Burning-Glaſs is three Foot in Diameter; it collects the Rays of the Sun at ten Foot Diſtance, where it forms a Focus of about three Inches over, which is again contracted by means of another Glaſs-Lens to an Inch Diameter, and conſequently is rendered three times as ſtrong.

I ſhall

I ſhall only relate here what I have obſerved upon the four Imperfect Metals, *viz.* Iron, Copper, Tin and Lead: I ſhall ſay nothing at preſent of Gold or Silver; becauſe as their Analyſis ſeems to me much more difficult than of the other Metals; I ſhall forbear Inquiries upon them, till I have examined as far as poſſible into the Nature and Compoſition of the former.

What was a great Hindrance to me in making theſe Experiments in the Focus of the Glaſs, was the Difficulty I had to find any Matter capable of holding the Metals in fuſion.

Charcoal, which is commonly made uſe of, is indeed a very proper Subſtance; but it is impoſſible with it to vitrify any one of the Metals: The Particles of the Metal, when held any long time in fuſion in the Focus of the Glaſs, diſſipate and fly away in Fume or ſmall Particles; and as long as any part remains, that little that does remain, is always metallick, until the whole be quite evaporated.

The Reaſon of which I take to be this. Charcoal is a Subſtance deeply impregnated with oily or ſulphurous Parts (if I may ſo call them.) The firſt Effect that Fire has upon Metals is to ſeparate the ſulphurous Parts: now, if in proportion as the Sulphur is ſeparated from the Metal, the Body that ſupports the Metal furniſhes it anew with other ſulphurous Parts, the other Principles will never ſeparate, and the Metal will always remain Metal. And nothing but the greateſt Degree of Fire is able to raiſe and ſeparate the Sulphur, and that but by little and little, and in very ſmall Particles.

I had then recourſe to another Matter, that could not any ways be ſuſpected of containing any oily Parts. *Tſchirnhaus* (to whom we are obliged for making of theſe large Glaſſes, and the firſt Experiments that have been made with them) ſays, he has vitrified Metals by holding them in *China*-Ware. It is true, this ſucceeds pretty well, provided the Pieces be very thick, and the Glazing taken off: But the Difficulty I had to find a ſufficient Quantity of thick and proper *China*-Ware to make all theſe Experiments, forced me to have recourſe to more common Subjects, as well as ſuch, if poſſible, as were leſs capable of melting.

Of all the different Sorts of Matter that I made Trial of, what ſeemed beſt were the common Coppels and Plates of grey Fire-ſtone. The Coppels hold the Metal a long Time in fuſion in the Focus of the Glaſs without melting; excepting Lead, which eaſily runs through them as ſoon as it vitrifies, and helps to diſſolve them. The Plates of Fire-ſtone bear the Heat of the Focus much longer than any other Matter; but great Care is to be taken in heating them without breaking, 'till they become red hot, and when they are hot the leaſt cold Air makes them melt. Nevertheleſs this is the only Subſtance that I have uſed with moſt Succeſs, to hold Metals a long Time in fuſion, though with the greateſt Caution that was poſſible, to avoid the Inconveniencies aforementioned.

An

Another thing that has hinder'd me from carrying on theſe Inquiries upon Metals ſo far as I could have wiſhed, has been the few clear Days we have had for theſe two Years paſt; for the greateſt Part of theſe Experiments require a bright, ſtrong, and conſtant Sun to keep the Matter a long Time in perfect fuſion: And I have ſcarce had, for this laſt Year, above three or four ſuch Days as I could wiſh for; the Sky having been almoſt every Day cover'd with Clouds about Noon, which is the only Time of the Day fit for theſe Experiments.

On Iron. I placed in the Focus of the Burning-Glaſs a Piece of forged Iron of about a Drachm Weight: It turn'd red hot, and its Surface was cover'd with a black Matter like Pitch or Tar. If one withdraws the Iron out of the Focus in this State, this Matter fixes itſelf on the Surface of the Metal, and there forms a ſmall Skin or a very fine blackiſh Scale, which is commonly very eaſily ſeparated by ſtriking upon it; and that Part of the Iron that was cover'd with this Scale appeared blacker than ordinary. This Scale is ſome of the ſulphureous Part of the Iron that riſes to the Surface of the Metal when it is ready to melt, and there remains for ſome time before it exhales. It is plainly this ſulphureous Part, that riſes upon Iron and poliſhed Steel when heated, and gives them all thoſe different Colours, from a Yellow, to a Violet, Water-colour, or Black.

If one continues to hold this Piece of Iron on the Charcoal, it intirely melts; and at the ſame Time caſts forth very bright Sparks in a great Quantity, ſometimes to above a Foot diſtance from the Coal.

If one ſaves what flies off during this ſparkling, by holding a Sheet of Paper under the Coal; we find that they are ſo many very ſmall Globules of Iron, and the greateſt Part of them hollow.

All the Iron that is held in fuſion upon the Coal, flies away in ſparkles after this manner, 'till none remains. Sometimes the Metal leaves off ſparkling, when the Coal is in part conſumed, and cover'd with a Bed of Cinders, upon which lies the melted Iron. For as the ſparkling of the Iron ſeems to me to proceed from nothing but the oily Parts of the Coal acting upon thoſe of the Metal, the Cinders hinder this Oil from paſſing from the Coal to the Iron, ſo that it remains quietly in fuſion. But if thro' any Shake, or the like Accident, the Cinders are ſo removed, that the Iron comes to touch immediately the Coal, it will begin to ſparkle afreſh. Sometimes the Heat, that keeps in fuſion the Metal, vitrifies alſo the Cinders; and this vitrified Matter mixing with the Metal makes a conſiderable Ebullition. If one at this Inſtant withdraws the Metal out of the Focus, it appears half vitrified, or reduced to a blackiſh friable Maſs. Other times this vitrified Matter ſwims on the Surface of the Metal, and there forms itſelf into Drops, that are ſometimes clear and tranſparent, and other times opaque, according as it is more or leſs mixed with the Metal.

Further-

Furthermore, if after having let the melted Iron cool upon the Coal, one expoſes it again to the *Focus* of the Glaſs upon the Stone, it ſparkles afreſh till it is all conſumed; which common Iron will not do, that has not been expoſed to the Heat of the *Focus* upon Charcoal. This ſparkling probably proceeds from the ſudden Rarefaction of the oily Parts of the Coal, with which the Pores of the Iron are ſo plentifully ſaturated; or perhaps it may be cauſed by the Salts of the Iron acting on the Oil of the Coal.

I expoſed to the *Focus*, upon a Stone-ſlate, Iron and Steel: they grew red hot, and melted without crackling or caſting off any Sparks: they ſmoaked very conſiderably, and the melted Metal turned by little and little like an Oil. After having withdrawn this melted Matter out of the *Focus*, it fixed in a Regulus-like, friable Maſs, and appeared ſometimes lightly ſtriated, or ſhot into ſharp Points like Needles. Tho' this Matter does not appear at all tranſparent, yet we may look on it as the Beginning of Vitrification, or a middle State between Metal and Glaſs; for it would vitrify in the End like other Metals, if one could hold it a ſufficient Time in the Focus without melting or mixing with what ſuſtains it: But continuing it long in the Focus, the extreme Heat of the Sun, that is neceſſary to keep it in perfect fuſion, melts likewiſe the Stone or Coppel that contains it, the Reſult of which Mixture is a brown or greyiſh Sort of Ennamel.

We may then take this Regulus Maſs to be a half vitrified Iron, by reaſon it is deprived of a great Part of its Sulphur. If one adds to this Maſs a Sulphur like that which was taken from it, from being friable it turns very hard and malleable; and the dulneſs it had before, changes to the Brightneſs of a Metal. This is what I have experienced in expoſing again this Matter to the Focus upon Charcoal: it melts, and ſo continues a conſiderable Time in fuſion without ſparkling, but at laſt it ſparkles with the ſame Briſkneſs as Iron itſelf; and when withdrawn from the Focus, appears nothing different from melted Iron.

It appears from theſe Experiments, that Iron contains a Sulphur or oily Subſtance, that renders it bright, malleable, and eaſy to melt.

That this Sulphur is raiſed by the Fire of the Sun, when the Metal is for ſome time held in fuſion in the Focus of the Glaſs.

That this ſame Sulphur may be raiſed by the Flame of common Fire, which tho' not ſtrong enough to melt the Iron, yet is able to reduce it to an Eſchar or ſort of Ruſt.

That Iron deprived of this ſulphureous Part, melts into a Regulus, or brittle and friable Maſs, in Colour much like Antimony.

That if one can hold a ſufficient Quantity of this Matter long enough in the Focus by itſelf, without melting or mixing with the Body that contains it, it perfectly vitrifies.

That this Glaſs or metallick Regulus, with the Help of a little Oil, returns to its former State of a Metal.

That it reaſſumes this metallick Form upon Charcoal, by drawing thence this oily Subſtance.

That, in ſhort, this oily Part contained in the Coal, is little different from the Sulphur of Iron. Nevertheleſs we muſt imagine it to differ in ſome Particulars; in that melted Iron, that has been ſaturated with it, crackles and ſparkles very much when melted again upon the Stone or Coppel.

Iron being the only Metal in which I have obſerved this ſparkling, I take it to be a Property peculiar only to Iron, and not to any other Metal. Perhaps we may attribute it to the vitriolick Salt that this Metal ſo plentifully abounds with, which is very greedy of Sulphurs.

To this ſame greedineſs alſo, with which the vitriolick Salt of Iron abſorbs the oily Part of the Coal, we may attribute the Eaſineſs with which Iron conſumes the Coal; for there is no other Metal that ſo ſoon waſtes the Coal in the Focus of the Glaſs, as Iron does.

Another Obſervation is, that it is the only one of the four imperfect Metals, on which vitrified Drops ariſe, while it is in fuſion upon the Coal: The Reaſon of which I have not yet been able to diſcover.

On Copper. Copper expoſed to the Focus of the Burning-Glaſs, at firſt turns white on its Surface, and afterwards grows black, and is covered with a kind of Skin, or black, furrowed, and uneven Scales, till at laſt it quite melts.

I have withdrawn this Metal out of the Focus, as ſoon as this white Colour has appear'd, and after it has been cold, found nothing extraordinary on its Surface, which has again by little and little recover'd very near the ſame Colour as it had before.

I have not been able to diſcover, from whence this white Colour proceeds; unleſs we may attribute it to ſome volatile arſenical Salt contained in the Copper, and driven by Extremity of Heat to the Surface of the Metal; or whether it purely proceeds from the Alteration that is made in the groſſer Parts of the Surface of the Metal when it begins to melt. The black Colour that Copper afterwards takes, ſeems to be cauſed by the ſulphureous Matter that melts firſt in this Metal as well as Iron, and is raiſed to its Surface by the extreme Heat.

I placed a Piece of Copper in the Focus upon Charcoal: It melted, and emitted a very thin Fume, and by little and little diminiſhed till it was all evaporated.

I put a Piece of red Copper on a Coppel into the Focus of the Glaſs: it melted, and ſent forth ſome thin Fumes; and after it had been ſome time in fuſion, it turned liquid like an Oil. I withdrew this melted Matter, and as it grew cold, it fixed into a Regulus of a reddiſh brown Colour, which was hard, brittle, and not ductile under the Hammer. If one breaks it, it turns into a red Powder like Cinabar of Antimony; and when viewed with a Microſcope, appears ſo many little, red, tranſparent Grains like ſmall Rubies; inſomuch that one

one would readily take this Regulus to be a deep coloured red Glaſs.

I endeavoured to make this vitrified Copper ſpread abroad in melting, by mixing it with common white Glaſs; for which End I powder'd ſome of this vitrified Copper and common Glaſs, and mixing them, melted them together; but the Mixture when in fuſion took at firſt a beautiful green Colour, and continuing it longer in the Focus, it turned blewiſh. I believe we may attribute this Change of Colour to the Alcali Salts of the Glaſs acting on the Particles of Copper; for thoſe Salts uſually draw a green or blewiſh Tincture from this Metal.

To preſerve therefore this red Colour of the vitrified Copper, when mixed with common Glaſs, I made uſe of this Expedient. I melted in the Focus upon a Coppel a Piece of Copper, and as ſoon as it began to vitrify I caſt upon it ſome common Glaſs; as ſoon as the Glaſs was melted, I took them together out of the Focus without confuſing them; and as ſoon as they were cold, ſeparated the Regulus from the Glaſs as well as poſſible; and picked out of it ſome Pieces of the Glaſs, loaded with ſome very ſmall red tranſparent Particles of the Regulus.

This vitrified Copper is then nothing but Copper, deprived, by means of Heat, of the ſulphureous Part, that gave it the Form of a Metal. A Proof, that this metallick Form proceeds from nothing elſe but this Sulphur, is, that if one expoſes this vitrified Copper to the Focus upon Charcoal, it reaſſumes in a little time the Colour and Conſiſtence of melted Copper; and as it grows cold, fixes into a good red malleable Copper, as fine and hard, as it was before it was vitrified.

It follows from theſe Experiments, that the Baſis of Copper is a red Earth ſuſceptible of Vitrification.

That this Earth receives its metallick Form from a ſulphureous Subſtance, in Appearance no ways different from the Oil of Vegetables or Animals.

That one may deprive Copper of this Oil, by holding it long enough in the Focus, or by calcinating it in the Flame of common Fire.

That Charcoal reſtores again this oily Part to Copper, and at the ſame time its metallick Form.

It appears further, that the Oil of the Coal has not ſo conſiderable an effect upon Copper, as it has upon Iron.

Copper expoſed a long Time to the Focus upon a Stone or Coppel, fumes very much, and diminiſhes in Weight very conſiderably. I don't think that this Fume is only the ſulphureous Part of the Metal, the Evaporation of which muſt be inſenſible; but I believe that with this Oil there is mixed a great deal of the earthy, vitrifiable Part of the Metal, which the Heat of the Sun ſublimes and raiſes in Flowers.

On Tin. Tin expoſed upon Coal to the Focus of the Burning-Glaſs, melts and emits a groſs, white, thick Fume, until it is all conſumed in Vapours.

If one melts Tin upon a Coppel in the Focus of the Glaſs, it fumes very much, and its Surface is covered with a white rarefied Calx; on which by little and little ariſes a Tuft, or Heap of ſharp, needle-like, tranſparent chryſtalline Particles, conſiſting of an infinite Number of ſmall Points.

If one continues to hold this Maſs in the Focus upon the Stone, theſe Chryſtals at length leave off fuming, and remain fixt, while the Stone melts and vitrifies.

I took Calx of Tin, which is Tin reduced to a grey Powder by means of Fire, that has taken away by Calcination great Part of its oily Subſtance, and expoſed it on a Coppel to the Focus, where it fumed again very much, and was reduced into ſharp chryſtalline Particles conſiſting of other ſmall Points.

In re-expoſing theſe chryſtalline Particles to the Focus upon Charcoal, they melted very eaſily, and took again the Form of Tin; the Coal having furniſhed them with the ſulphureous Part that the Fire had before taken away. Every Body knows, that if one add any Fat, or the like inflammable Matter, to the Calx of Tin, when red hot in the Crucible, it reaſſumes immediately the Form of Tin.

Theſe Experiments ſhew, that Tin contains a Sulphur that is very eaſily ſeparated, ſince common Fire can do it ſo readily; and that this Metal calcined, or deprived of its Sulphur, is eaſily ſaturated again with it from the oily Part of any inflammable Matter whatſoever.

It proves alſo, that the metallick Earth, which is the Baſis of Tin, is a chryſtalline Earth, very difficult to be melted; ſince common Fire cannot vitrify this Metal by itſelf, and that the Heat of the Sun, in the Focus of this large Burning-Glaſs of the *Palace-Royal*, cannot perfectly melt the Calx, into which this Metal is reduced. We may preſume that the Chryſtalliſation, or reducing of this Metal into ſharp-pointed Particles, proceeds from the Force of the Sun's breaking and melting together into a Sodder (if I may ſo ſpeak) ſome of theſe ſmall Chryſtals, by Degrees, as the ſulphureous Part leaves them; it not being ſtrong enough to melt them all down together in one intire Maſs.

On Lead. I took Lead, and held it in fuſion upon Charcoal in the Focus of the Glaſs: it all waſted away in abundance of Fumes.

I expoſed the like Quantity of Lead upon a Stone to the Focus, where it caſt forth great Quantities of Fumes, and by little and little changed into a fluid Liquor like Oil or melted Roſin. This Liquor, as it grew cold, fixed into Glaſs; which has this peculiar to itſelf, that it is diſpoſed into Plates like *Venetian* Talk, and that it is flabby, ſoft

ſoft to the Touch, tranſparent, and in ſome Parts of a greeniſh or reddiſh Yellow.

In continuing this Matter in the Focus, it ſpread upon the Stone like Varniſh; and at laſt penetrating it, helped to melt it.

I placed this talky Earth in the Focus upon Charcoal: It melted, and in a little Time after reaſſumed the Form of melted Lead. I withdrew it from the Focus, and having let it cool, found it nothing different from Lead.

Theſe Experiments ſhew, that there is in Lead, as well as the other imperfect Metals, a ſulphureous Part, that is eaſily ſeparated by common Fire or the Heat of the Sun; and that this Metal has for its Baſis a foliated or talky Earth.

On Quickſilver.

I ſhall add here ſome Experiments, that I have made upon Quickſilver; though I cannot yet draw any poſitive Concluſions from them, not having proſecuted them ſo far as is neceſſary for that Purpoſe.

I placed Quickſilver in the Focus of the Burning-Glaſs upon Charcoal, upon the Coppel, and upon the Stone: It all immediately diſperſed, and exhaled in a very thick Fume.

I expoſed upon the Stone to the Focus ſome Mercury *Precipitate per ſe*, in a Degree of Heat equal to that of Digeſtion: It ſeemed to melt, but preſently diſperſed in Vapours; there remained a ſmall Quantity of a very rarefied Duſt like a Froth or Scum; but continuing it in the Focus, it melted, and gathered into a yellowiſh Glaſs, in which one might diſtinguiſh ſome Particles of Metal like Silver.

I expoſed ſome Mercury *Precipitate per ſe* upon Charcoal: It fumed very much; and as it melted, one might ſee little Globules of Mercury unite and form themſelves together upon the Coal, but they diſperſed again preſently in Vapours.

Theſe Experiments ſeem to prove, that there is in Quickſilver a Sulphur, that may be ſeparated by a very gentle Heat, ſuch as that of Digeſtion.

That as ſoon as this Sulphur is taken away, it loſes its Fluidity and Brightneſs.

That the Baſis of Mercury is a Calx, or red Earth.

That this Calx does not melt into Glaſs as the Calx of other Metals, becauſe it is too volatile, and as ſoon as it melts is evaporated by the Heat.

That if one reſtores to this Calx a Sulphur, by expoſing it again to the Focus upon Charcoal, it reaſſumes immediately its metallick Brightneſs and Fluidity, and becomes Quickſilver.

I cannot tell whether this light Earth, that remains upon the Stone after the Evaporation of the Calx of the Mercury, be a Part of the Earth of the Mercury more exactly deprived of its Oil, and conſequently more fixt and proper for Vitrification; or whether it may not be ſome Matter foreign to the Mercury, that fixes itſelf, and remains behind

behind at its Evaporation. But this I ſhall examine more particularly hereafter.

The Reſult of all theſe Experiments is, that theſe four Metals which we call imperfect, *viz.* Iron, Copper, Tin, and Lead, are compoſed of a Sulphur or oily Subſtance, and of a metallick Earth capable of Vitrification.

That from this Sulphur proceeds the Opacity, Brightneſs, and Malleability of a Metal.

That this metallick Sulphur does not appear at all different from the Oil of Vegetables or Animals.

That it is the ſame in Mercury as in the four imperfect Metals.

That theſe four Metals have for their Baſis, an Earth ſuſceptible of Vitrification.

That this Earth is different in every one of theſe four Metals; in that it vitrifies differently in each of them.

And that on this Difference in vitrifying depends the Difference of Metals.

It remains, that I ſhould examine more particularly the Nature of theſe Earths or metallick Vitrifications; to know if any other Principles or Subſtances may be ſeparated from them: But this I ſhall endeavour to do hereafter, in proſecuting the Analyſis of theſe Metals, as far as poſſible.

Experiments with Mr. Villette's *Burning-Glaſs in* June, *by Dr.* J. Harris, *and Dr.* J. T. Deſaguliers, n. 360. p. 976.

VI. This Miroir is a Concave 47 Inches wide, and ground to a Sphere of 76 Inches *Radius*; ſo that its *Focus* is about 38 Inches diſtant from the *Vertex* of the Glaſs. The Metal of which it is made is a Mixture of Copper, Tin and Tin-Glaſs, whoſe Reflexion has ſomething of a yellow Caſt. The Concave-Surface has ſcarce any Flaws, and thoſe very ſmall; but the Convex-Side, which is alſo poliſhed, has ſome Holes in it.

Having held ſeveral Bodies in the *Focus* of this Miroir, we obſerved what happened to them whilſt expoſed to this great Heat; and with a a half-ſecond Pendulum, took Notice of the Time in which any material Change happened to them.

The Experiments were as follow, and made from nine till twelve in the Morning.

N° 1. A red Piece of a *Roman Patera*, which began to melt in 3 Seconds, was ready to drop in 100.

2. Another black Piece melted at 4, and was ready to drop at 64 Seconds.

3. Chalk taken out of an *Echinus Spatagus* filled with Chalk only, fled away in 23 Seconds.

4. A Foſſile-Shell calcin'd in 7 Seconds, and did no more in 64.

5. A Piece of *Pompey*'s Pillar at *Alexandria*, was vitrified in the black Part in 50 Seconds, and in the white Part in 54.

6. Copper-Oar, that had no Metal in it viſible, vitrified in 8 Seconds.
7. Slag, or Cinder of the ancient Iron-work ſaid to have been wrought by the *Saxons*, ready to run in 29 Seconds and an half.

Here the Glaſs growing hot, burned with much leſs Force.

8. Iron-Oar fled at firſt, but melted in 24 Seconds.
9. Talk began to calcine at 40 Seconds, and held in the *Focus* 64.
10. *Calculus humanus* in 2 Seconds was calcined, and only dropped off in 60.
11. An anonymous Fiſh's Tooth melted in 32 Seconds and an half.
12. The *Asbeſtos* ſeemed condenſed a little in 28 Seconds; but it was now ſomething cloudy: Monſ. *Villette* ſays, that the Glaſs uſually calcines it.
13. A golden Marchaſite broke to Pieces, and began to melt in about 30 Seconds.
14. A ſilver Sixpence melted in 7 Seconds and an half.
15. A King *William*'s Copper Halfpenny melted in 20 Seconds, and ran with an Hole in it 31.
16. A King *George*'s Halfpenny melted in 16 Seconds, and ran in 34.
17. Tin melted in 3 Seconds.
18. Caſt Iron in 16 Seconds.
19. Slate melted in 3 Seconds, had an Hole in 6.
20. Thin Tile melted in 4 Seconds, had a Hole and was vitrified through in 80.
21. Bone calcin'd in 4 Seconds, and vitrified in 33.

An Emerald was melted into a Subſtance like a Turquois Stone.

A Diamond weighing 4 Grains loſt $\frac{1}{8}$ of its Weight.

VII. Experience (as well as the Authority of Dr. *Hook* in his Preface to his *Micrographia*) aſſures us, that ſingle Magnifying-Glaſſes (when they can be uſed) are preferable to Microſcopes, compoſed of two or more Magnifying-Glaſſes: Nor are the late Improvements made by Magnifying-Glaſſes, ſo much owing to the making *Them*, and compoſing *Microſcopes*, as to the *Methods* of applying Objects for the *Advantage* of Light; in which, I hope, the following deſcribed *Inſtruments* will not be found inferior to any yet made, at leaſt commonly ſold. *A Pocket-Microſcope, by Mr.* J. Wilſon, n. 281. p. 1241.

This *Set* of Microſcopes has eight different Magnifying-Glaſſes; ſeven of which may be uſed with two different Inſtruments, for the better applying them to various Objects: One of theſe Inſtruments is repreſented *Fig.* 72. *AAAA*, and is made of Ivory, it has three thin Braſs Plates *E E*, and a Spring of Braſs *H* within it; to one of the thin Plates of Braſs is fixed a Piece of *Cork F*, with a Concavity *G*..... both in the Cork and Braſs, to which it is affixed: In one End of this Inſtrument Fig. 72.

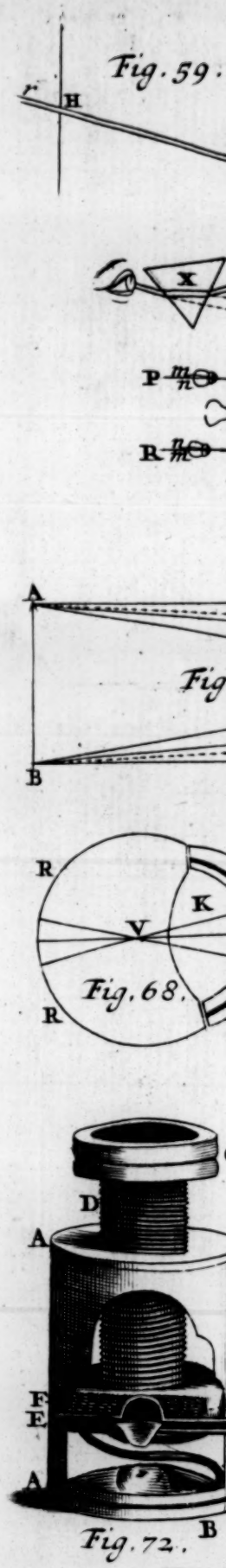
Inſtrument there is a long Screw *D*, with a Glaſs *C*, ſcrewed in the End of it: In the other End there is a hollow Screw *o o*, wherein any of the Magnifying-Glaſſes are ſcrewed when they are to be made Uſe of. The 8 different Manifying-Glaſſes are all ſet in Ivory, 7 of which are ſet in
Fig. 76. the Manner of *Fig.* 76. *n.* 4. The greateſt Magnifyer is marked upon the Ivory, wherein it is ſet, with *n.* 1. the next *n.* 2. and ſo on till *n.* 7. the 8th Glaſs is not marked, but ſet in the Manner of a little Barrel
Fig. 74. Box of Ivory, as in *Fig.* 74.

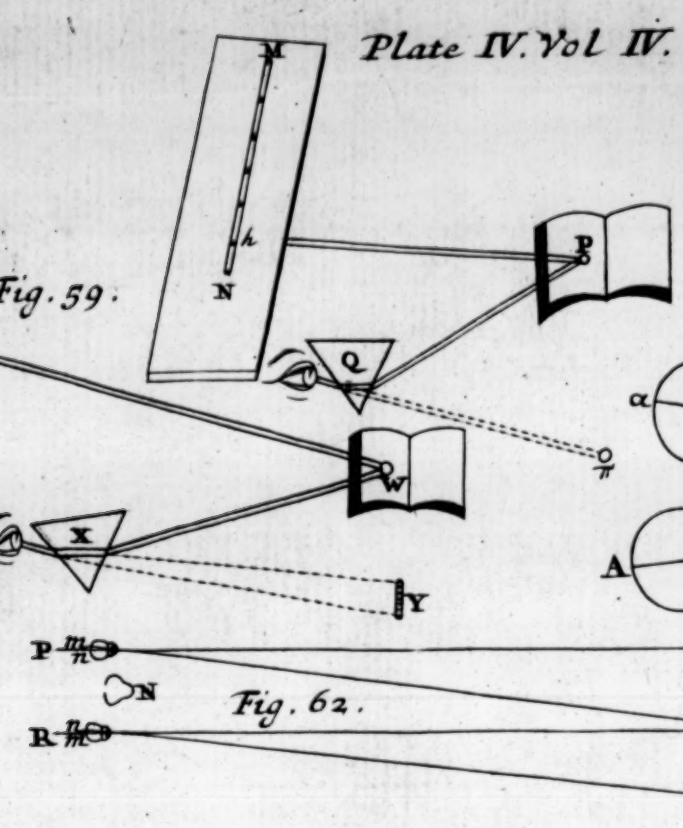
Fig. 73. *Figure* 73 is a flat Piece of Ivory *e e*, whereof there are 8 belonging to this Set of Microſcopes, (though any one, who has a Mind to keep a Regiſter of Objects, may have as many of them, as he pleaſes) in each of which there are 3 Holes *f f f*, wherein 3 or more Objects are placed between two thin Glaſſes or Talks, when to be uſed with the greateſt Magnifyers.

Fig. 75. The Inſtrument *Fig.* 75. is made of Braſs or Prince's Metal, with Joints *P P P*, to turn eaſily any way with a ſmall Pair of Tongs *G G*, which open at the Points *k*, by preſſing together the two Heads of the Pins *I I* for taking up of Objects: There is a round Piece of Ivory *H*, ſcrewed upon the other End of the Tongs, white on one Side for black Objects that are opaque Bodies (ſuch as are Seeds or Sands) and black on the other Side for white ones of that Nature.

Fig. 76. Upon the ſharp End *A*, of this Braſs Inſtrument, all the 8 Glaſſes may be fixed, as you ſee *Fig.* 76. *n.* 4. there being a Hole in the Ivory wherein the Glaſſes are ſet for that Purpoſe, with a thin Piece of Braſs *B* in the manner of a Spring, that holds it firmer: So when any Object is taken up in the Points of the Tongs *k*, or laid upon the other End *H*, it may be very eaſily (as any one who ſees the Inſtrument will perceive) applied to the true Diſtance of any of the Glaſſes, by the Help of the Joints *P P P P*, as alſo the Screw *C*, and Wheel *D*, which will bring the Object to the Exactneſs of the *Center* or true Diſtance, being regulated by a Spring *E*.

Fig. 72. Fig. 73. The Uſe of the firſt mentioned Inſtrument, *Fig.* 72. *A A A A*, is thus: Take one of the flat Pieces of Ivory *e e*, or *Regiſters*, *Fig.* 73. (as they may be called) and ſlide it in betwixt the two thin Plates of Braſs *E E*, in the Body of the Microſcope, *Fig.* 72. ſo that the Object, you intend to look upon, be juſt in the middle, remarking that you put that Side of the Plate *e e*, where the Ring is furtheſt from your Eye: Then you are to ſcrew into *o o* (the hollow Screw in the End of the Body of your Microſcope,) the 3d, 4th, 5th, 6th, 7th Magnifying-Glaſs; which being done, while you are looking through the Magnifying-Glaſs upon the Object, you are to ſcrew in or out the long Screw *D* in the other End of the Body of the Microſcope, till you bring the Object to the true Diſtance; which you will know by ſeeing the Object clearly, and diſtinctly: But ſince in the greater Magnifyers you can ſee but a ſmall Part of the Object, *viz.* the Legs or Claws of a Flea; while you are looking upon any Part of the Object, if you take hold of the End of the





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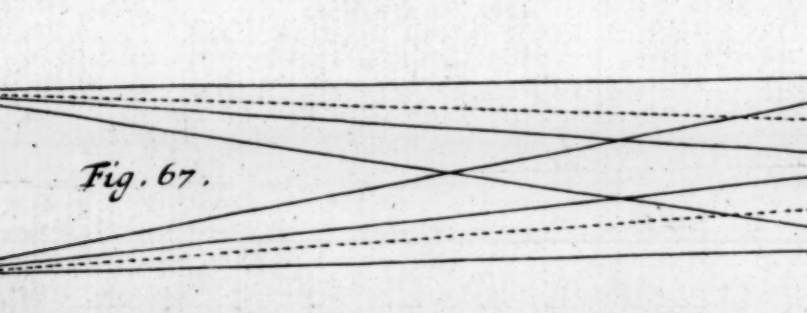
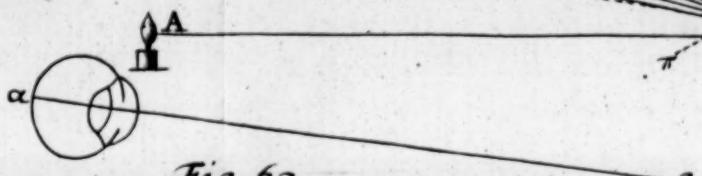


Fig. 62.

Fig. 60.



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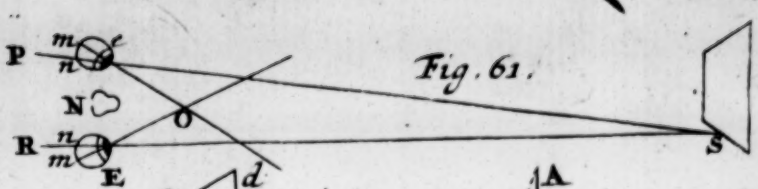

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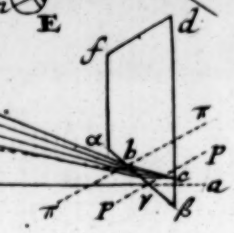

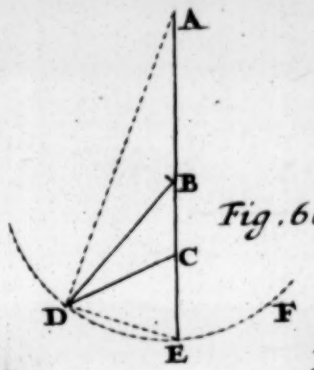

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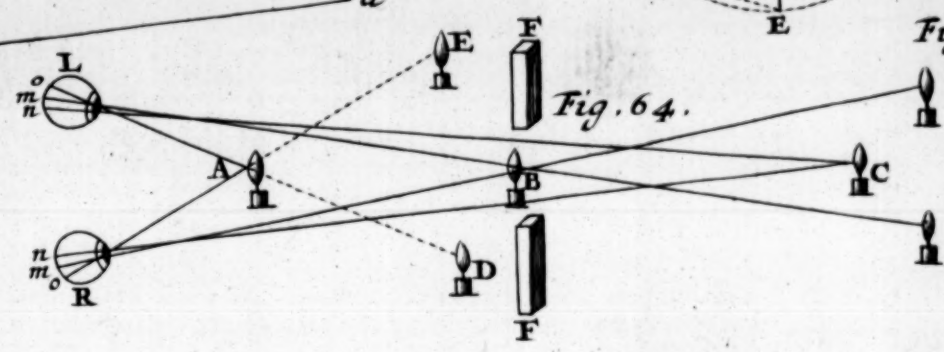

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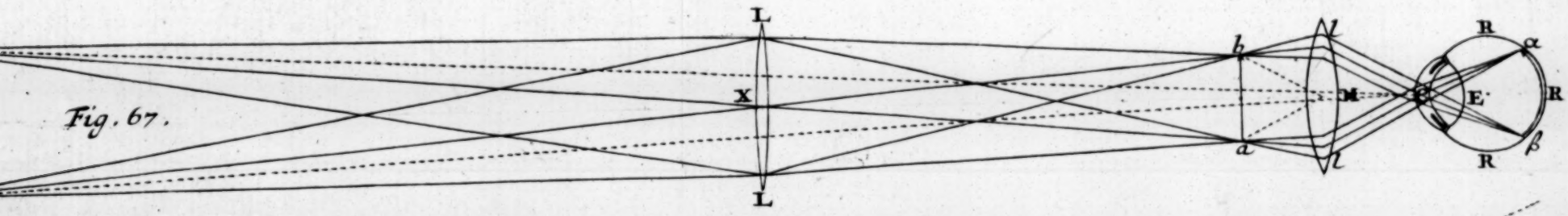

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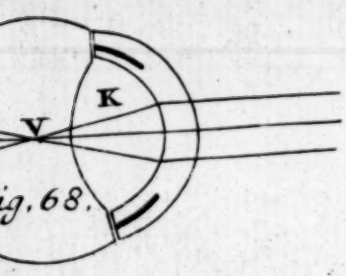

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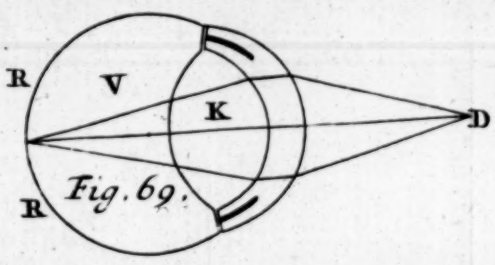

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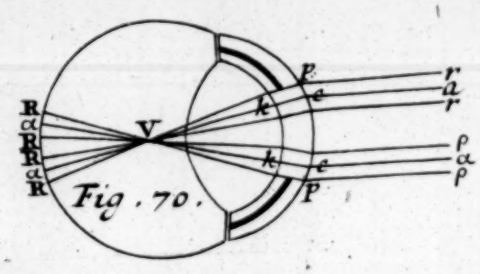

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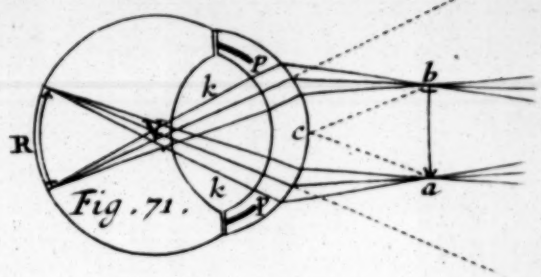

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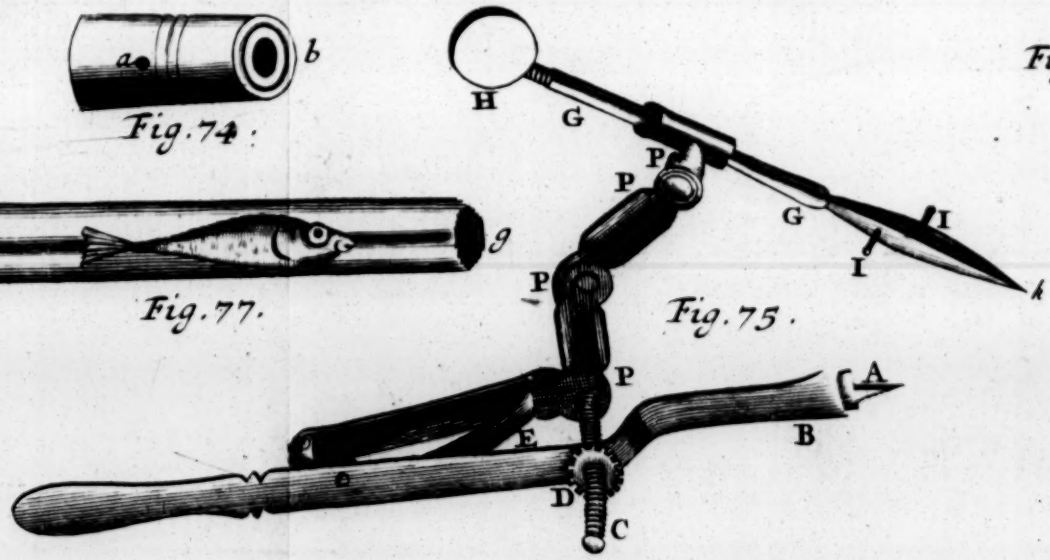


Fig. 75.

Fig. 76.

the Plate *e e*, whereon the Object lies, and move it gently, you may ſee the whole Object ſucceſſively, or any Part of the Object you pleaſe; and if that Part of the Object, you deſign to look upon, be out of the true Diſtance, remember your End-ſcrew *D* can always bring it in, by ſcrewing it nearer or farther off. Fig. 73.

After this Manner may be ſeen all tranſparent Objects, Duſts, Liquids, Chryſtals of Salts; ſmall Inſects, ſuch as Fleas, Mites, *&c.* If they be Inſects that will creep away, or ſuch Objects as one intends to keep, they may be placed between the two *Regiſter-Glaſſes f f*. For by taking out with the Point of a Penknife the Ring that keeps in the Glaſſes *f f*, where the Object lies, they will fall out of themſelves; ſo you may lay the Object between the two hollow Sides of them, and put the Ring in as it was before: But if the Objects are Duſts or Liquids, a ſmall Drop of the Liquid, or a little of the Duſt laid on the outſide of the Glaſs *f f* and applied as before, will be ſeen very eaſily. Fig. 73.

As to the firſt and ſecond Magnifying-Glaſſes, being marked with a Croſs upon the Ivory wherein they are ſet, they are only to be uſed with thoſe *Regiſter-Plates*, that are alſo marked with a Croſs, wherein the Objects are placed between two thin Talks, becauſe the Thickneſs of the Glaſſes in the other Regiſters or Plates hinders the Object from approaching to the Centre, or true Diſtance of theſe great Magnifyers. But the manner of uſing them is the ſame with the former; only remember when you put in or pull out the ſame Plate or Regiſter *e e* (whereon the Object lies) or move it from one Object to another, not to let it rub your Magnifying-Glaſs, which is done by unſcrewing a little the End-ſcrew *D*, when you put in or pull out the Plate, or move it from one Object to another. Fig. 73. Fig. 72.

For ſeeing the *Circulation* of the *Blood* at the Extremities of the *Arteries* and *Veins*, in the tranſparent Parts of Fiſhes, Eels, *&c.* there are two Glaſs-Tubes, the one bigger and the other leſſer, is deſigned in *Fig.* 77. wherein the Fiſh is to be put; when this leſſer Tube is uſed, you are to unſcrew the Endſcrew *D* in the Body of the Microſcope until the Tube *g g*, *Fig.* 77. can eaſily enter into that little Cavity *G* of the Braſs-Plate faſtened to the Cork *F*, under the other two thin Plates of Braſs *E E*; when the Tail of your Fiſh lies flat to the Glaſs-Tube, ſet it oppoſite to your Magnifying-Glaſs, and by ſcrewing in or out the End-ſcrew *D*, as is ſaid before, you may eaſily bring it to the true Diſtance, and ſee the Blood circulate with great Pleaſure. Fig. 77. Fig. 72.

When the bigger Tube is to be uſed with a larger Fiſh or Frog; then you are to take out the Braſs-Plate *G F* faſtened to the Cork, by preſſing down the other two Plates *E E*, and the Spring *H*, to the End of the Microſcope *B*; and by turning the Cork and Braſs-Plate *G F* ſideways, you may eaſily take it out and put it in again; when the Cork-Plate *G F* is out, the larger Tube will eaſily enter into the Body of the Inſtrument, and is to be uſed as the other leſſer one. Fig. 72.

If you would ſee the Blood circulate in a Frog's Foot, chuſe ſuch a Frog as will juſt go into your Tube, then with a little Stick expand the hinder Foot of the Frog, and apply it cloſe to the Side of the Tube, obſerving that no Part of the Frog hinders the Light coming on its Foot; and when you have it at the juſt Diſtance by Means of the Screw *D*, as aboveſaid, you will ſee the rapid Motion of the Blood, in its Veſſels, which are very numerous, in the tranſparent thin Membrane that is between the Frog's Toes: For this Object the 3d and 4th Magnifyers will do very well; but you may ſee the Circulation in the Tails of *Water-Newts* with the 5th and 6th Glaſs, by Reaſon the Globules of the Blood of thoſe Newts are as big again as the Globules of the Blood of Frogs or ſmall Fiſh, as has been taken Notice of by Mr. *Cowper* in N°. 280, of theſe *Tranſactions*.

Vid. infra V. v. C.VI. S. iii.

N. B. The Circulation cannot be ſo well ſeen by the 1ſt and 2d Magnifyers, becauſe the Thickneſs of the Glaſs wherein the Fiſh lies, hinders the Approximation.

Fig. 74. The Glaſs placed in the manner of a Barrel-Box, *Fig.* 74. is only to be uſed with the Braſs Inſtrument (or in your Hand) being the leaſt Magnifyer, for greater Objects, ſuch as Flies and common Inſects, *&c.* The Hole *a* in the Side of this Box is to be fixed on the Point *A* of the Braſs Inſtrument, remembring to put the End *b* next your Eye, and the other to the Object; ſo if you take up any In-

Fig. 75. ſect in the Point of the Tongs *k*, or lay any opaque Object on *C* the other End, you may approach them to the true Diſtance, by the Help of the Joints and Screw *C*, *D*, *P*, *E*, (ſpoken of before) and ſee them diſtinctly.

In the viewing of Objects, one ought to be careful not to hinder the Light from falling upon them, by the Hat, Peruke, or any other thing, eſpecially when they are to look upon opaque Objects: For nothing can be ſeen with the beſt of Glaſſes, unleſs the Object be in a due Diſtance, with a ſufficient Light.

The beſt Light for the Plats or Regiſters, (where the Object lies between the two Glaſſes) is a clear Sky-light, or where the Sun ſhines on any white thing, or the Reflection of the Light from a Looking-Glaſs. The Light of a Candle is likewiſe good for the Circulation of very ſmall Objects, though it be a little uneaſy to thoſe who are not practiſed in Microſcopes to find out the Light of the Candle; but Uſe will make every thing eaſy.

For the Conveniency of thoſe who would *draw* or make any Sketches or *Deſigns* after Microſcopical Objects, I have alſo made a *Pedeſtal* to fix the two Inſtruments above deſcribed, and make them ſtationary to any convenient Light. This Pedeſtal may be placed on a Table, *&c.* and after the Object, and Light are fixt, as many Perſons as pleaſe may view the Object, without any Trouble or Difficulty in finding the Light.

The

The following Figures were drawn by this Microſcope from ſeveral Objects: *Some* Objects *viewed with this Microſcope.*

A, *B*, *C*, *D*, *E*, *F* repreſent the Feathers of the Wings of *Butterflies* and *Moths*; *A*, *B* are the ſame, but differently magnified. *A* was expreſſed by the 4th Glaſs, and *B* as it appeared by the 1ſt. The reſt being taken from different Parts of thoſe *Inſects*, *C*, *D*, *E*, *F* were all viewed by the 4th Glaſs. Fig. 78.

G. is one Grain of the *Farina* of the *Capilaments* of *Maloes* by the *firſt* Glaſs. Fig. 79.

HH is the *Tail* of a ſmall *Fiſh*, viewed when living by the 4th Glaſs; *i i* is the Part of the Tail next the Body of the Fiſh, where the Trunks of the *Veins* and *Arteries* paſs together. *I I I I* their *Extremities* which appear united, *k k k* other *Inoſculations*, with the *Arteries* and *Veins* appearing in the tranſparent Membrane, between the Cartilages *K K*. *L L L L* the *Cartilages* compoſed of ſeveral Joints, on each Side of which the Trunk of a Vein and Artery paſſes. *M* an *Animalculum*, whereof a great Number appeared moving themſelves up and down on the Tail of the Fiſh, while the Circulation was viewing. Fig. 80. Fig. 81.

N. repreſents a Side-view of the ſame *Animalculum*. Fig. 82.

O is another *Animalculum* of a different Figure from the former, that ſtuck to the Tail of the Fiſh by its jagged extremity, and frequently drew its long Body out and in again. Fig. 83.

P Q one of the *Lice* found on the *Beetle*, called *Scarabeus Pediculoſus* by the 4th Glaſs. *P* its *Anus*. *Q* its two Claws, not unlike thoſe of a Lobſter, *r r r r* the Extremities of its Feet, which have a remarkable Contrivance for ſticking faſt to the poliſhed Surface of the Beetle, not in the manner of Claws, as many other Inſects; but divided into Capilaments, as expreſſed in the Figure. Fig. 84.

S the ſame *Animal* as it appeared to the naked Eye. Fig. 85.

VIII. I think that all the Microſcopes which preceded Mr. *Leeuwenhoeck*'s, are ſo much outdone by his, that it will be proper only to take Notice of theſe and the reſt of later Invention, not deſigning to leſſen their Uſefulneſs, but only to add a few Thoughts which may be of Service. *The Manner of making* Microſcopes, &c. *by Dr.* A. Adams, n. 325. p. 24.

I had not an Opportunity of examining Mr. *Leeuwenhoeck*'s Glaſſes particularly, which is a Favour he allows to none; therefore I am not capable at this Diſtance to deſcribe either their Make or Uſe, any further than that to me they appeared to be Spherules lodged between two Plates of Gold or Braſs, in a Hole whoſe Diameter might not be bigger than that of a ſmall Pin's Head; and the Objects I ſaw through them were pretty and diverting; but ſtill their Make and Truth are unknown.

Mr. *Butterfield* is very curious in melting his Glaſs, but I ſuppoſe unſucceſsful in caſting his Spheres; for beſides that a ſufficient Quantity of beaten Glaſs cannot ſtick to the moiſtened Point of a fine Needle;

ſo neither can it run equally, hold the Needle how you will, nor the *Globule*, when run, ſtick to the Needle, but muſt unavoidably drop; and whereſoever it happens to fall, it muſt in that almoſt liquid State receive Impreſſions ſufficient to ſpoil the Figure of a Sphere.

Mr. *Gray* has ſhewn the Defect of his Method, which he uſed to recover by grinding and poliſhing his Glaſſes on a Braſs-Plane, and ſo reduce them to Hemiſpherules; but how far ſhort poliſhed Glaſſes (I ſpeak of ſmall ones) come of thoſe which are caſt, I leave to any one to judge who has ſeen both. His Water and Quickſilver Microſcopes I never ſaw, ſo can ſay little to them.

After what manner Mr. *Wilſon*'s Glaſſes are made I know not, but ſure his greateſt Magnifiers are ill placed, they being ſunk to ſo great a Diſtance from the Eye, the Object cannot appear to that Advantage it otherwiſe would; if therefore inſtead of a hollow Cap he would contrive a plain Plate of any Metal for the Reception of the Glaſs, then the Eye and the Object might come to their due Diſtance; neither ought there to be any Calx or Glaſs between the Object and the Spherule, when we uſe the greateſt Magnifiers; becauſe if the *Focus* of a Sphere be upon the Extremity of its Circumference, any ſmall Diſtance from that muſt ſpoil the Truth of the Object's Appearance.

I cannot ſay, that the Glaſſes I have made are without Fault, but I think they magnify more than any I have yet ſeen; and were they placed to the beſt Advantage, they would magnify much more than they do: They are made thus.

I take a Piece of fine Window-Glaſs, and I raſe it with a Diamond into as many Lengths as I think needful, not exceeding an Eighth of an Inch in Breadth; then holding one of theſe Lengths between the Fore-Finger and Thumb of each Hand, over a very fine Flame, until the Glaſs begins to ſoften, I draw it out till it be as fine as a Hair and break: Then inuring each of the Ends into the pureſt Part of the Flame, I have two Spheres preſently, which I can make larger or leſs as I pleaſe; if they ſtay long in the Flame, they'll have Spots, ſo I draw them out preſently after they turn round. As for the Stem, I break it off as near the Ball as I can, and lodging the Remainder of this Stem between the Plates, and by drilling the Hole exactly round, all this Protuberance is buried between the Plates, and the Microſcope performs to Admiration; inſomuch, that the ſame Thread of very fine Muſlin appeared 3 or 4 times bigger in one of theſe, than it did in the firſt or ſecond of Mr. *Wilſon*'s. I thought I ſaw Animals in fine Old Brandy, but they were ſo nimble in their Motion, that I can give no particular Deſcription of them. Human *Blood* is ſo far from ſhowing any red *Globules* ſwimming in *Serum*, that immediately after its *Emiſſion* it appears to be a Body of infinite Branches, running in no certain Order, variouſly coloured; where it lies thickeſt on the Glaſs, it's of a dull Red; where thin, inclining to Yellow; but

A Remark on Blood.

but the whole ſo blended as to repreſent very near the Top of a Yew-Tree in a very fine Landſkip, having its ſuppoſed Branches of a red and yellow confuſedly intermixt. But not ſatisfied with this Appearance, though the ſame as to Quality in eleven different Glaſſes, and as many different Sorts of Blood, I reſolved to view it another way, which was, by diluting one Third of Thick in the *Serum* of Blood; and laying it upon my Glaſs, I could ſee the red Branches as before, and the tranſparent filled with Particles of great variety of Figures, which I took to be the Salts of the Blood, but feweſt globular, and they were pellucid.

If the Fluids moving in an evaneſcent Artery appear globular, I ſuppoſe it's becauſe the Canal is round, which alters the Caſe much.

on Pleuritic *Blood.*

I had at the ſame Time an Opportunity of viewing ſome *Pleuritic* Blood; and thought that its Branches did ſpread in a different Method from the Sound, and more ſtrongly perplexed with overthwart Branches, which appeared black like Blood that had ſtood two or three Days. Whether the Attraction of Particles ariſing from the Difference of Figure, may not render the Blood incapable of paſſing thro' the Capillary Arteries of the *Pleura* in that Caſe, let others judge; but I ſhould think, that ſince the Propellent Force of the Heart is leaſt at the Capillary Arteries, then there the attractive Force of the Particles of the Blood ſhould be greateſt; and ſince Spherical Bodies are the moſt attractive of any, reſpect being had to their Solidities, were the Blood ſo plentifully ſtocked with Globules, as ſome ſay, we ſhould never be free from Obſtructions, the natural Conſequence of this attractive Force. If my Glaſſes have deceived me, and if this that I have written be found to be a Miſtake, no one ſhall more readily retract and acknowledge it.

IX. *Account of a Book omitted.*

N. 344. p. 300.

Linear Perſpective, or a *new* Method of *Repreſenting* juſtly all manner of Objects, *&c.* By *Brook Taylor*, LL.D. and R. S. *Secr.* 8vo. London, 1715.

An Addition ibid. p. 303.

The Author having in his *Book* obſerved, that there might be a very good *Expedient* made uſe of in painting of large Rooms and Churches, which is drawn from the Nature of thoſe Rays which produce the *Vaniſhing Points*, but not having mentioned it in his Book, has thought proper to take Notice of it in the *Account*.

The *Expedient* is this: Having ſome way or other found the Repreſentation of one Point of a Line that is wanted in the Picture, to find the whole Line, paſs a Thread ſtretched through the Place of the Spectator's Eye, in a Direction, parallel to the Direction the original Line ought to be in, and the Shadow of that Thread caſt by a Candle, ſo as to paſs through the given Point on the Picture will be the Repreſentation ſought. The Reaſon of this Conſtruction is, becauſe the

the Rays of Light that paſs from the Candle to the Thread ſo ſtretched, make the Plane which generates the Repreſentation ſought; (*Vid.* Prop. 1.) and there may be other Expedients of the like Nature gathered from the ſame Principle.

CHAP. III.

ASTRONOMY.

Of Caſſini's *Orbit of the* Planets, *by Dr.* Gregory, n. 293. p. 1704.

I. EX quo Celeberrimus D. *Caſſini*, in *Tractatu de Origine & Progreſſu Aſtronomiæ*, Curvam quandam pro Planetæ Orbita Aſtronomis propoſuit, & de ipſius Curvæ natura, & de Gravitatis lege ad eam percurrendam requiſita, variè multumque ab eruditis diſputatum eſt; mihi etiam de eadem denuo cogitanti cum diverſæ ejus ſpecies, tum & harum proprietates aliquæ nondum ſatis perſpectæ occurrebant.

Fig. 86. Satis notum eſt iſtius Orbitæ hanc eſſe naturam. Si a datis duobus punctis *F* & *G* ad quodvis curvæ punctum *H* ducantur rectæ *FH*, *GH*; rectangulum ſub *FH*, *GH* æquale eſt dato ſpatio. Recta *FG* hinc inde producta donec curvæ occurat, oſtendit Vertices *A* & *B*; & *AB* eſt Axis principalis; mediumque inter vertices punctum *C* eſt figuræ Centrum; & *DE*, per *C* ad *AB* normalis, Axis minor; punctaque *F* & *G* Foci.

In hac figura, ſi axis minor excedat diſtantiam focorum, Curva figuram terminans eſt ubique versùs centrum cava, qualis vulgo habetur. Si, manente axe principali, diſtantia focorum minuatur, augebitur axis minor, qui tamen minor manet axe Ellipſis eodem axe principali, iiſdemque focis deſcriptæ; donec tandem, coeuntibus focis, ille evadat æqualis axi majori, & figura abeat in Circulum. Si vero, e contra, diſtantia focorum augeatur; minuetur axis minor, fietque æqualis dictæ diſtantiæ, cum hæc eſt ad axem principalem, ſicut unitas ad medium proportionalem inter unitatem & ternarium.

Si ulterius augeatur diſtantia focorum, minuetur adhuc axis minor, & Curva non erit amplius ad hujus extrema verſus centrum cava,
Fig. 87. ſed convexa, ut in *Schemate* 87, donec auctâ eouſque diſtantiâ focorum, ut hæc ſit ad axem majorem ſicut latus quadrati ad ejuſdem diametrum, axis minor fiat nullus, & curva pertingat ad centrum hinc inde.

Fig. 88. Si diſtantia focorum fuerit major quam pro dicta ratione, axis minor fit impoſſibilis, & figura in duas conjugatas abit, ut in *Schemate*

88. quæ auctâ focorum diſtantiâ minuentur, donec tandem figura in bina puncta conjugata abeat.

Creſcente porro diſtantiâ focorum, rurſus emergunt binæ figuræ conjugatæ, quæ ſimiliter creſcunt atque prius decreverant a proribus diverſæ in focorum verticumque ordine, augenturque donec infinitæ evadant. Poſteaque Syſtema hoc iiſdem gradibus ad circulum rurſus accedet quibus ab illo receſſit.

Ex his vel primo intuitu ſatis patet, Figuram hanc ad conſtituendam Planetæ Orbitam minime idoneam eſſe. Ut enim taceam caſus, ubi in duas conjugatas abit, Orbitæque naturam deponit, nimirum ubicunque tanta ſit ejus excentricitas, quantam Cometæ (ſi circa Solem Planetarum inſtar verſentur, quod veriſimillimum eſt) ad curſum ſuum deſcribendum poſtulant: ut hos inquam caſus præteream, ſunt etiam in ijs caſibus, ubi in ſe redit orbitamque perficit, quædam ejus excentricitates ita amplæ, ut curva prope *D* & *E* verſus Solem convexa evadet; adeoque vi a Sole centrifugâ Planetæ opus eſſet, ut hanc Orbitæ ſuæ partem percurreret, dum interim in locis propioribus & remotioribus *B* & *A* vis ad Solem centripeta requiritur. Id eſt corpora circumſolaria eâ lege moveri poſſe concedendum eſſet ut in paribus a Sole intervallis hic vis centripeta, illic centrifuga obtineret, quod quam ſit a naturæ legibus alienum facile omnes perſpicient. Et licet nullius e Planetis tanta ſit excentricitas, cum tamen Geometris notum ſit figuræ, cujus ſpecies omnes ultra certum terminum muneri cuivis naturæ obeundo ineptæ fuerint, ejus ſpecies reliquas citra dictum terminum, quaſi eidem muneri idoneas, admitti non poſſe: Neceſſe eſt. *Curvam hanc Caſſinianam ex Aſtronomia rejicere*, non ſolum ob rationes *Prop.* VIII. *Lib.* III. *Elem. Aſtr.* adductas, nempe, *quod neque obſervatis cæleſtibus congruat propter minoris axis brevitatem, neque rationes Phyſicæ reſpondeant, cum ad illam deſcribendam opus eſſet vi centripetâ ad Solem, abhorrente ab illa per rerum naturam uſurpata*; ſed etiam propter abſolutam impoſſibilitatem. Impoſſibile namque eſt hujus figuræ ſpeciem quamcunque poſſe a Planeta percurri, ita ut anguli ad ſocum a Sole diverſum proportionales ſint temporibus; ſic enim area per radium vectorem deſcripta non eſſet tempori proportionalis. Non enim aucto angulo ad focum unum æqualibus incrementis, areæ ad alterum incrementa ſimul facta etiam æqualia ſunt, uti perperam nuper ſentiebam.

In Figuris 87, 88 maxima figuræ latitudo invenitur, ſi centro *C* per ſocos deſcribatur circulus; ſecabit namque hic Curvam in punctis *L*, *L* quæſitis. Eſtque maxima ordinata *KL* tertia proportionalis rectis *GF* & *FD* in horum primo, vel quarta proportionalis ipſis *GF*, *GA*, & *AF* in utroque. Fig. 87. Fig. 87, 88.

Superſtite *DE*, ordinata ex foco *FP* æqualis eſt ſemi-axi minori *CD*, quando axis minor eſt ad diſtantiam focorum ut latus quadrati ad diametrum. Si diſtantia focorum fuerit major quam pro hac ratione, *FP* excedet *CD*.

II. *Kep-*

The Newtonian *Solution of* Kepler's *Problem demonſtrated, &c. by Dr.* J. Keil, n. 337. p. 1.

II. *Keplerus* primus demonſtravit, Planetas non in Orbibus Circularibus, ſed Ellipticis, deferri; Solemque in Ellipſeos focorum uno ſitum ea ratione circumire, ut Radius à Planeta ad Solis centrum protenſus, ſemper verrat Areas Ellipticas, quæ temporibus quibus deſcribuntur ſunt proportionales.

Divinum hoc ſagaciſſimi *Kepleri* inventum, exactiſſimis *Tychonis Brahe* Obſervationibus debetur; & tanto magis eſt ſuſpiciendum, quòd iſtius ope, Motuum leges, totiuſque Mundani Syſtematis Philoſophiam feliciſſimè patefecerit *Newtonus*,

Cum itaque tali lege moveantur circa Solem Planetæ quo ipſorum loca in propriis Orbitis ad datum tempus determinentur, neceſſe eſt ut ſolvetur *Problema* quod ſequitur.

Invenire Poſitionem rectæ, quæ per datæ Ellipſeos focum alterutrum tranſiens, abſcindat Aream motu ſuo deſcriptam, quæ ſit ad Aream totius Ellipſeos in ratione data.

Fig. 89. Sit nempe Ellipſis APB, cujus focus alteruter S. Invenienda eſt poſitio rectæ SP, quæ abſcindat Aream trilineam ASP, ad quam Area totius Ellipſeos eandem rationem habet, quam tempus Periodicum Planetæ Ellipſim deſcribentis, ad aliud tempus datum; quâ inventâ dabitur punctum P, ubi Planeta ad tempus illud datum verſatur. Vel ſit AQB ſemicirculus ſupra Ellipſeos axem majorem deſcriptus, ducenda eſt per S recta SQ, abſcindens Aream ASQ, ad quam Area totius circuli eſt in eadem ratione: ſi enim ex Q demittatur in Axem perpendicularis QH, Ellipſi occurrens in P, ducta SP dabit Aream Ellipticam quæſitam; & punctum P erit locus Planetæ ad datum tempus. Eſt enim ſemiſegmentum Ellipticum APH ad ſemiſegmentum circulare AQH, ut HP ad HQ, hoc eſt, ut area totius Ellipſeos ad aream totius Circuli; ſed eſt triangulum SPH ad triangulum SQH in eadem ratione PH ad QH: Adeoque Area ASP eſt ad Aream totius Ellipſeos, ut area ASQ ad aream totius Circuli. Unde ſi habeatur methodus ſecandi in datâ ratione Aream circuli, rectâ ductâ per datum punctum S, facile erit hac ipſa ratione ſecare Aream Ellipticam.

Ipſi *Keplero*, qui primus Problema propoſuit, nulla innotuit Methodus directa computandi locum Planetæ ex dato tempore; ſed illi neceſſe fuit, per ſingulos gradus ſemicirculi AQB progrediendo, ex dato arcu AQ, quam vocat Anomaliam Excentri, tam tempus per aream ASQ, quæ Anomaliæ mediæ eſt proportionalis, quam angulum ASP, hoc eſt locum Planetæ, ſeu Anomaliam coæquatam huic tempori reſpondentem, calculo eruere.

Cum itaque difficilis fuit hujus Problematis ſolutio, Aſtronomi ad alias tranſiverant Hypotheſes, fingendo punctum aliquod, circa quod motus foret æquabilis, ſeu tempori proportionalis, & exinde datâ Anomaliâ mediâ, coæquatam determinabant. Sed computus hiſce hy-

pothesibus innixus, obſervationibus non congruere deprehenſus eſt: Itaque Geometræ varias adhibuerunt approximationes, quibus ex datâ Areâ ASQ tempori Analoga, angulus ASP, hoc eſt Planetæ locus, quam proxime eliciatur. At horum omnium facillima, & ad Praxim maxime expedita, mihi videtur eſſe illa methodus, quam tradit Dominus *Newtonus* in *Principiis*, *pag.* 111. & 112. *Edit. 1mæ.* quæ fere ſimilis eſt ei, quâ ex æquationibus affectis extrahunt Radicem Analyſtæ; & quidem tanto magis eſt æſtimanda, quod non ſolum exhibeat Planetarum loca, quorum orbitæ ad Circuli formam proxime accedunt, ſed eadem fere facilitate inſervit etiam Cometis, qui in orbitis maxime excentricis moveantur.

Hanc itaque methodum in gratiam Artificum, qui Tabulas Aſtronomicas ſecundum veras motuum leges, & non ex fictis hypotheſibus condere volunt, hic exponendam duxi.

Sit itaque AQB ſemicirculus ſupra Axem majorem Ellipſeos deſcriptus, cujus centrum C, & focus in quo Sol locatur ſit S. Ducatur CQ, in quam (ſi opus ſit) productam cadat perpendicularis SF. Eſt Area ASQ = ſectori ACQ + Triang. $CSQ = \frac{1}{2} CQ \times AQ + \frac{1}{2} CQ \times SF$; adeoque ob datam $\frac{1}{2} CQ$ erit Area ASQ ſemper proportionalis arcui AQ + recta SF, cum ſcil. motus ſit ab Aphelio verſus Perihelium: at cum à Perihelio ad Aphelion tendit Planeta, ut in *Figurâ* 92, fit Area BSQ = ſectori BCQ — Triang. CSQ, adeoque erit illa proportionalis arcui BQ — recta SF. Hinc ſi capiatur Arcus AN in *Fig.* 90 & 91. & BN in *Fig.* 92. temporibus proportionalis, erit $AQ + SF = AN$, & $BQ - SF = BN$: unde SF erit $= QN$, modo arcus AN vel BN ſint proportionales temporibus quibus deſcribuntur areæ ASQ vel BSQ. Ut vero inveniatur in gradibus eorumque partibus menſura arcûs in peripheria AQB, qui ſit æqualis rectæ SF. Fiat ut CQ ad CS ita arcus graduum 57,29578 (qui æqualis eſt CQ radio) ad arcum quartum, qui æqualis erit CS. Sit arcus ille B. Eſt autem CS ad SF ut Radius ad ſinum anguli SCF vel ACQ. Fiat itaque ut Radius ad ſinum anguli ACQ vel arcûs AQ, ita arcus B ad alium D; erit arcus ille D æqualis rectæ SF, adeoque ſi, ad datum tempus, Area ASQ eſſet tempori proportionalis, eſſet Arcus $D = NQ$: & capiendo arcum $NP = D$, punctum P caderet in Q. Si vero Area ASQ non exactè tempori reſpondeat, punctum P cadet ſupra vel infra Q, prout Area ASQ major ſit vel minor verâ Areâ quæ tempori reſpondeat. Sit ea ASq & in Cq cadat perpendicularis SH: erit per hactenus demonſtrata $SH = Nq$. At eſt $SF = NP$, unde erit $SH - SF$ vel $SF - SH$, hoc eſt fere $HE = qP = QP - Qq$ vel $= Qq - QP$: Et ſi angulus QCq ſit parvus, erit $CH : CQ :: HE : Qq :: QP - Qq : Qq$, unde $CQ + CH : CQ :: QP : Qq$, cum arcus AQ eſt quadrante minor. At cum is eſt quadrante major, erit $CQ - CH : CQ :: QP : Qq$. Et ſimiliter cum arcus BQ eſt quadrante minor, erit $CQ - CH : CQ :: QP : Qq$.

Fig. 90.

Fig. 90,91,92.

Si angulus ACQ vel BCQ parvus ſit, *h. e.* ſi Planeta prope Apſides verſetur, erit ut $CA \pm CS : CA :: QP : Qq$.

Fiat ut CS ad CQ ita Radius R ad longitudinem quandam L, erit $CQ = \frac{CS \times L}{R}$. Eſt vero Radius ad coſinum anguli ACQ ut SC ad CF vel CH (ſunt enim CH & CF fere æquales) quare erit $CH = \frac{SC \times cof.\ ACQ}{R}$; adeoque $QP : Qq ::$

$\frac{CS \times L \pm CS \times cof.\ ACQ}{R} . \frac{CS \times L}{R} :: L \pm cof.\ ACQ : L$, cum arcus AQ ſit quadrante minor. At ſi AQ ſit quadrante major, erit $QP : Qq :: L - cofin.\ ACQ : L$.

Atque hac ratione ſi capiatur utcunque arcus AQ, qui aliquantiſper minor ſit aut major vero, invenietur exinde arcus Qq huic addendus aut demendus, qui facit ut Area ASq ſit quam proxime tempori proportionalis. Et ſi loco AQ capiatur arcus Aq, & inſtituatur proceſſus priori ſimilis, invenietur alius Aq, qui ſimiliter eundem repetendo proceſſum dabit alium Aq, atque ſic quantumvis proxime ad veritatem accedere licebit.

Invento angulo ACq, facile habebitur angulus ASq, cum in triang. qCS dentur latera Cq & CS & angulus qCS. Dabitur exinde angulus CSq cujus tangens diminuendus eſt in ratione axis minoris Ellipſeos ad majorem, ut tandem habeatur tangens anguli ASP. Vel ſic forte facilius inveſtigatur angulus ASP. Sit F numerus qui exprimit longitudinem CS in partibus qualium CQ eſt 100000: a puncto q ad axem demittatur perpendicularis qr, qui erit ſinus arcus dati Aq, & erit Cr ejuſdem coſinus & $Sr =$ ſummæ vel differentiæ rectarum Cr, CS, hoc eſt $Sr = F \pm$ coſin. ACq: adeoque in rectangulo triangulo rSq, datis Sr, rq, invenietur angulus rSq. Hinc ſi in unam ſummam addantur ſinus Log. ang. ACq, complementum Arithmeticum Logarithmi Sr, & Logarithmus rationis axis minoris Ellipſeos ad majorem, dabitur Tangens anguli ASP.

Tanta autem eſt hujus methodi facilitas ut ea exemplis magis quam ulteriori explicatione indigeat; adeoque licebit eam in motibus Planetæ Martis experiri, in cujus orbita, ſecundum Tabulas *Carolinas*, Excentricitas eſt ad diſtantiam mediam ut 14100 ad 152369, adeoque Logarithmus arcus B, qui æqualis eſt rectæ SC, erit 0,7244451. Erit etiam in hoc exemplo L partium 1080631 qualium Radius eſt 100000: Inveniendus ſit angulus ACQ cum motus medius, ſeu arcus tempori proportionalis, ab Aphelio computatus, ſit unius Gradus. Quoniam CS ſit hic fere pars decima ipſius CA, pono Arcum AQ eſſe 0,9 grad. decima

ma ſcil. parte minorem motu medio. Addatur ſinus Logarithmicus arcus AQ ad Log. B, & fit ſumma 8,9205471 = Log. numeri 0,083281 qui numerus exprimit arcum æqualem rectæ $SF = NP$. Et ſi arcus AQ eſſet recte aſſumptus, foret $AN - NP = AQ$, & $QP = 0$. At hic eſt $QP = 0{,}016719$, a quo ſi auferatur ejus pars undecima, cum AS ſuperat AC undecima circiter ipſius parte, reſtabit $Qq = 0{,}0152$; qui additus ad AQ dat $Aq = 0{,}9152$, qui ne milleſima gradus parte a vero Aq differt. Sit ſecundò Arcus AN ſeu motus medius = 2 gr. Pono $AQ = 1{,}83$ prioris Aq fere duplum, & ad ejus ſinum Log. addatur Log. B. erit ſumma 9,2286997 = Log. numeri 0,16931, unde erit QP 0,00069; a quo ſi ſubducatur ejus pars undecima, fit $Qq = 0{,}00063$, & $Aq = 1{,}83063$, qui ne decies milleſima gradus parte à vero Aq diſcrepat. Eodem modo ſit motus medius, ſeu arcus tempori proportionalis grad. 3. Fiat arcus AQ 2,745 = 1,83 + 0,915, & ad ejus ſinum Log. addendo Log. B, habebitur Log. numeri 0,25392 = NP, & $AN - NP = 2{,}74608$, adeoque $QP = 0{,}00108$, unde Qq fere = 0,001 & $Aq = 2{,}746$. Sic unica duorum Logarithmorum additione invenietur arcus Aq, qui erit verus ad gradus partes milleſimas.

Si jam non gradatim ſed per ſaltum pergendo, inveniendus ſit angulus ACq, cum motus medius eſt grad. 45. Pono arcum AQ eſſe graduum 40, & ad ſinum ejus Logarithmicum addendo Log. B fit ſumma 0,5325125 = Log. numeri 3,4081; qui numerus à 45 ſubductus relinquit $AN - NP = 41{,}5919$, cujus exceſſus ſupra arcum AQ eſt 1,5919. Unde ſi fiat ut L + coſ. ACQ ad L ita 1,5919 ad alium, invenietur arcus Qq eſſe graduum 1,4865, adeoque $Aq = 41{,}4865$, qui non multum ſupra milleſimam gradus partem à vero differt. Verum abſque hac proportione inveniri poteſt Aq, capiendo novum arcum AQ, qui ſit aliquantulum minor quam $AN - NP$, eidem tamen fere æqualis; ſcil. ſit $AQ = 41{,}50$, & addendo Log. datum B ad ejus ſinum Log. habebitur alter $NP = 3{,}35131$, qui ab AN ſubductus dat 41,4869 pro novo Aq: & hic arcus minore labore eruitur, & aliquanto propius ad verum accedit quam prior Aq.

Poſt inventum Aq correſpondentem motui medio 45°, rurſus gradatim pergendo, unica duorum Logarithmorum additione, habebitur Aq, ad omnes motus medii gradus ſubſequentes. Nempe cum motus medius ſit grad. 46, pono $AQ = 42{,}40$. & addendo ejus ſinum Log. ad conſtantem B, fiet $AN - NP = 42{,}4249$; cui arcui ſi novus AQ æqualis ponatur, habebitur Aq, qui ne milleſima gradus parte à vero Aq diſcrepabit. Sic cum motus medius ſit 47°, pono $AQ = 43{,}36$ = priori Aq + incremento iſtius arcus pro uno gradu motus medii, & addendo ejus ſinum Log. ad Log. B, fit ſumma = Log. numeri 3,6402, qui ab AN ſubductus relinquit $AN - NP = 43{,}3598$ = novo Aq, qui circiter gradus parte decies milleſima à vero Aq diſcrepat.

Si omissis gradibus intermediis inveniendus esset arcus Aq, cum motus medius sit gr. 100. Pono $A\mathfrak{Q}$ grad. 96, & addendo ejus sinum Log. ad Log. B, fit summa = Log. numeri 5,273 unde, $AN - NP = 94{,}727$. Itaque pono secundo $A\mathfrak{Q} = 94{,}72$ & addendo ejus sinum ad Log. B, habebitur Log. numeri 5,285, qui ab AN subductus dat $AN - NP = 94{,}715 = Aq$ quam proxime. Similiter si motus medius sit grad. 101, pono $A\mathfrak{Q}$ esse 95,71, cujus sinus Log. ad Log. B additus dat Log. numeri 5,2756; quo numero ab 101 sublato, restabit $AN - NP = 95,\ 7244 = Aq$. Atque hac ratione, dato motu medio, si gradatim fiat processus, habebitur angulus ad centrum per unicam tantum duorum Logarithmorum additionem; quorum unus, qui constans est, in charta seorsim servandus, quo labori sæpius eundem exscribendi parcatur.

Transeamus jam ad Orbitam alterius speciei, talem nempe ut distantia Aphelii sit ad distantiam Perihelii ut 70 ad 1; qualis fere est istius Cometæ Orbita quem Periodum suam annis $75\frac{1}{2}$ complere primus deprehendit Sagaciſſimus Astronomus & Geometra D. *Edmundus Halleius*. In hac Orbita, erit AC vel $C\mathfrak{Q}$ partium 35,5, & CS 34,4 qualium SB est una. Et inveniendus est arcus Bq cum motus medius est gradus pars centesima. Quoniam media distantia trigesies & quinquies circiter superat distantiam minimam, pono $B\mathfrak{Q} = 0{,}35$, cum motus medius est 0,01. In hac Orbita invenitur constans Log. $B = 1{,}7457133$. Hic itaque Log. ad sinum Log. arcus 0,35 additus, dat Log. numeri 0,34013, qui ad arcum 0,01 additus erit = 0,35013. Si hæc summa esset æqualis 0,35, arcus $B\mathfrak{Q}$ esset recte assumptus: sed differentia est 0,00013. Unde quoniam CB est ad SB ut 35,5 ad 1, multiplicetur differentia 0,00013 per 35,5, & prodibit $\mathfrak{Q}q = 0{,}004615$; unde erit arcus $Bq = 0{,}354615$, qui vix per partes tres decies-millesimas a vero discrepat.

Sit secundo motus medius 0,02, & ponatur $B\mathfrak{Q}$ esse 0,71. Ad ejus sinum Log. addendo Log. B, fit summa = Log. numeri 0,68998, unde $BN + NP = 0{,}70998$, adeoque arcus assumptus $B\mathfrak{Q} = 0{,}71$ nimius fuit: & est differentia = 0,00002, quæ si per 35,5 multiplicetur, & productus a $B\mathfrak{Q}$ subducatur, restabit $Bq = 0{,}7092$, vix gradus parte decies millesima à vero aberrans.

Sit motus medius 0,03. Ponatur $B\mathfrak{Q}$ esse 1°,06: addendo ejus Log. sin, ad Log. B, fit summa = Log. numeri 1,03008, cui si addatur $BN = 0{,}03$, fit summa 1,06008, qui numerus major est quam $B\mathfrak{Q}$; quare si differentia 0,00008 per 35,5 multiplicetur & ad $B\mathfrak{Q}$ addatur, erit $Bq = 1{,}06284$. Similiter cum motus medius sit 0,04, pono $B\mathfrak{Q} =$ 1°,40 & invenio $NP = 1{,}3604$; ad quem numerum addendo $BN =$ 0,04 fit summa = 1,4004 qui superat 1,40 per 0,0004. Multiplicetur hæc differentia per 35,5 & productus 0,01420 erit æqualis $\mathfrak{Q}q$, unde Bq = 1,41420. In hisce omnibus errores sunt admodum exigui, & raro millesimam gradus partem transcurrentes.

Inve-

Inveniendus ſit jam arcus Bq, cum motus medius ſit æqualis uni gradui. Pono $B\mathfrak{Q} = 20°$, & addendo ejus ſinum Log. ad Log. B, habebitur Log. numeri 19,045; cui addendo $BN = 1°$, ſumma 20,045 ſuperat 20 per ,045: Et cum in hoc caſu L—— coſin $B\mathfrak{Q}$ eſt ad L ut 1 ad 11,5 fere, multiplico differentiam ,045 per 11,5, & productus ,5175 ad $B\mathfrak{Q}$ additus facit 20,5175. Pono igitur ſecundo $B\mathfrak{Q} = 20{,}51$, & prodibit, ſimiliter ut in præcedentibus, $NP = 19{,}5092$; cui addendo BN fit ſumma 20,5092, quæ minor eſt quam $B\mathfrak{Q}$: unde ſi differentia 0,0008 multiplicetur per 11,5, & productus 0,0092 ſubſtrahatur a $B\mathfrak{Q}$, reſtabit $Bq = 20{,}5008$.

Sit denique motus medius æqualis duobus grad. Pono $B\mathfrak{Q}$ grad. 30, & invenitur $NP = 27{,}84$, cui addendo gradus duos, ſumma 29,84 minor eſt quam 30; & ſi multiplicetur differentia 0,16 per 6,3 (nam L— coſ. $B\mathfrak{Q}$ eſt ad L ut 1 ad 6,3 ferè) fiet $1{,}008 = \mathfrak{Q}q$; adeoque hic arcus a $B\mathfrak{Q}$ ſubductus dat $Bq = 28{,}982$: Ut vero corrigatur Bq, aſſumo ſecundo $B\mathfrak{Q} = 29°$, & ſimili proceſſu invenietur $Bq = 28{,}9672$.

The Parallax of the Sun to be found, by ſeeing *Venus* between the Sun and the Earth, *by Dr.* E. Halley, n. 348. p. 454.

III. Nullum Problema magis arduum videtur, quam eſt *Solis* a *Terrâ* Diſtantiam vero proximam determinare; quod tamen obtentis accuratis quibuſdam obſervationibus, ad electa & prævisa tempora peractis, non multo opere efficietur. Id quod huic Societati in hac diſſertatione ob oculos ponere libet: ut junioribus noſtris Aſtronomis, quibus forſan hæc obſervare ob minorem ætatem obtingere poteſt, viam præmonſtrem, quâ immenſam Solis diſtantiam intra quingenteſimam ſui partem rite dimetiri poterint.

Notum autem eſt, hanc diſtantiam à diverſis Aſtronomiæ authoribus diverſam fingi, prout cuique ex conjecturâ probabile viſum eſt; à *Ptolomæo* quidem ejuſque aſſeclis, uti & *Copernico* & *Tychoni Brahæo*, *Terræ* ſemidiametris mille & ducentis, *Keplero* ter mille quingentis fere. *Riccioli* diſtantiam *Keplerianam* duplicat, quam *Hevelius* dimidio tantum auget. At vero viſis in *Solis* diſco ope Teleſcopii Planetis *Venere* & *Mercurio*, mutuato fulgore nudatis, tandem compertum eſt Planetarum diametros viſibiles multo minores eſſe quam eatenus haberentur; *Veneriſque* Semidiametrum è *Sole* viſam, non niſi quartam minuti primi partem ſubtendere; *Mercuriique* ſemidiametrum, ad mediam ipſius à *Sole* diſtantiam, ſub angulo decem tantum ſecundorum conſpici; atque ſub eodem etiam *Saturni* ſemidiametrum è *Sole* videri. *Jovis* autem Planetarum maximi ſemidiametrum non niſi tertiam minuti primi partem apud *Solem* ſubtendere. Unde, ſervatâ analogiâ, nonnullis è modernis Aſtronomis viſum eſt, *Terræ* quoque ſemidiametrum è *Sole* conſpectam, medio loco inter *Jovis* majorem & *Saturni* & *Mercurii* minorem angulum ſubtendere, *Veneriſque* æqualem, nempe quindecim ſecundorum: adeoque *Solem* à *Terra* quatuordecim fere millibus ſemidiametrorum *Terræ* diſtare. Iiſdem vero Authoribus, aliud argumentum paulo ampliavit hanc diſtantiam: quoniam enim *Lunæ* diameter paulo major eſt quartâ parte diametri *Terræ*, ſi Parallaxis *Solis* ponatur quindecim

minutorum ſecundorum, fieret *Lunæ* corpus corpore *Mercurii* majus. Planeta ſcil. ſecundarius primario major; quod concinnitati Syſtematis mundani contrariari videretur. E contra vero *Venerem* inferiorem & Satellitio deſtitutam, majorem eſſe *Terrâ* noſtrâ ſuperiori & tam inſignem comitem nactâ, vix concedere videtur eadem concinnitas. Ut itaque medium teneamus, ponatur *Terræ* ſemidiameter è *Sole* viſa, ſeu quod idem eſt, *Solis* Parallaxis horizontalis, duodecim ſecundorum cum ſemiſſe: unde *Luna* minor erit *Mercurio* & *Terra Venere* major; ac proveniet *Solis* a *Terra* diſtantia ſedecies mille cum quingentis *Terræ* ſemidiametris proximè. Huic autem diſtantiæ inpræſentiarum aſſenſum præbeo, uſque dum *Experimento* quod proponimus quanta ſit certius conſtet. Nec moror authoritatem eorum qui *Solem* ultra hos terminos in immenſum evehunt, freti obſervationibus vibrantis Penduli, determinandis his angulorum minutiis, uti videtur, haud ſatis fidis: ſaltem hâc methodo tentanti Parallaxis aliquando nulla, aliquando etiam negativa occurret; hoc eſt diſtantia vel infinita fiet, vel infinito major: quod abſurdum. Quinetiam minuta ſecunda vel etiam dena ſecunda inſtrumentis, quantumvis affabre factis certo diſtinguere vix homini datum eſt; atque adeo minime mirandum, ſi tantorum Artificum multos & ingenioſos conatus hactenus eluſerit rei ipſius maxima ſubtilitas.

Dum autem ante 40 fere annos, in Inſula *Sanctæ Helenæ*, ſyderum polum Auſtralem ambientium obſervationibus operam darem; contigit mihi *Mercurium* ſub *Solis* diſco tranſeuntem omni adhibitâ diligentiâ obſervare: ipſum etiam momentum, quo *Mercurius* ingrediens *Solis* limbum interius contingere viſus eſt, pariturque momentum quo egrediens limbum Solis ſtrinxit, facto angulo contactûs interioris, Tubo optimo viginti quatuor pedum accuratiſſimè obtinui. Unde pro comperto habui intervallum quo *Mercurius* totus intra *Solis* diſcum tum temporis apparuit, etiam abſque errore unius minuti ſecundi temporis: Nam filum luminis Solaris, inter limbum planetæ obſcurum & *Solis* lucidum interceptum, quantumvis tenue in oculos incurrere viſum eſt: & in ictu oculi, denticulus in limbo *Solis* a *Mercurio* ingrediente factus evaneſcere, uti ab egrediente factus quaſi momento incipere. Hoc autem perſpecto ſtatim certior ſum factus *Solis* Parallaxin ex hujuſmodi obſervationibus rite concludi poſſe, ſi modo *Mercurius Terris* vicinior majorem haberet parallaxin à *Sole:* etenim hæc parallaxium differentia tantilla eſt, ut ſemper minor ſit ipsâ Solari quam quærimus; proinde *Mercurius*, licet frequenter intra *Solem* videndus, huic noſtro negotio vix ſatis idoneus habebitur.

Reſtat itaque *Veneris* tranſitus per *Solis* diſcum, cujus parallaxis, quadruplo fere major Solari, maxime ſenſibiles efficiet differentias, inter ſpatia temporis, quibus *Venus Solem* perambulare videbitur, in diverſis *Terræ* noſtræ regionibus. Ex his autem differentiis debito modo obſervatis, dico determinari poſſe *Solis* parallaxin etiam intra ſcrupuli ſecundi exiguam partem. Neque alia inſtrumenta deſiderantur præter *Teleſcopia* & *Horologia* vulgaria ſed bona: & in Obſervationibus non niſi fides

& diligentia, cum modicâ rerum Aſtronomicarum peritiâ. Non enim neceſſe eſt, ut Latitudo Loci ſcrupulosè inquiratur, nec ut Horæ ipſæ reſpectu meridiani accurate determinentur: ſufficit, Horologiis ad Cœli revolutiones probè correctis, ſi numerentur tempora à totali Ingreſſu *Veneris* infra diſcum *Solis*, ad principium Egreſſus ex eodem; cum ſcilicet primum incipiat Globus *Veneris* opacus limbum *Solis* lucidum attingere; quæ quidem momenta, propriâ experientiâ novi, ad ipſum ſecundum temporis minutum obſervari poſſe.

Ob leges autem motuum admodum arctas, rariſſime intra *Solis* orbem conſpicitur *Venus*, ac per plus quam centum & viginti annorum ſeriem, ne ſemel quidem ibidem videbitur; nempe ab anno 1639. (cum *Horroxio* noſtro, eique primo & ſoli à rerum conditu, hoc ſpectaculum obtigit,) uſquè in annum 1761, quo juxta Theorias quas hactenus cœlo conformes experimur, Stella *Veneris* iterum ſubtercurret *Solem*, *Maii* 26. mane; * ita ut *Londini*, horâ fere ſextâ matutinâ in medio diſci Solaris expectanda ſit, nec niſi quatuor minutis centro *Solis* Auſtralior. Duratio autem hujus tranſitus erit octo fere Horarum à ſecunda ſcilicet uſque in decimam fere matutinam. Atque adeo ingreſſus minime *Anglis* conſpicuus erit: cum autem Sol tum temporis occupaturus ſit 16. *Geminorum* gradum, viginti tres ferme gradus in Boream declinans; per totam quaſi Zonam frigidam Septentrionalem inocciduus conſpicietur: ac proinde qui littus *Norwegiæ* incolunt ultra Urbem *Nidroſiam*, quam *Drontem* vocant, uſque ad Promontorium ejus *Boreale*, *Venerem Solis* diſcum ſubingredientem obſervare poterunt; ac fortaſſe *Scotis* Borealioribus & Inſulæ *Hetlandiæ*, incolis, in oriente Sole ingreſſus ille conſpici poterit. Quo tempore vero *Venus Solis* centro proxima erit, *Sol* verticalis erit ſupra littora Borealia ſinus *Gangetici*, vel potius regni *Peguani*; ac proinde in Regionibus circumvicinis, cum *Sol* in ingreſſu *Veneris* quatuor fere horis diſtabit ad ortum, & in egreſſu totidem fere ad occaſum, accelerabitur motus apparens *Veneris* intra *Solem* duplo fere parallaxeos horizontalis *Veneris* à *Sole*; quia *Venus* tunc ab ortu in occaſum fertur retrogradê, interea dum oculus ad *Terræ* ſuperficiem poſitus in contrarias partes ab occaſu in ortum gyratur.

* *Vid.* V. 1. C. IV. S. C. p. 434, 436.

Poſitâ autem parallaxi *Solis* duodecim ſecundorum cum ſemiſſe erit parallaxis *Veneris* 43^{um} ſecundorum; & ſublatâ parallaxi *Solis*, reſtabit ſaltem ſemi-minutum pro parallaxi Horizontali *Veneris* à *Sole*, ac proinde dodrante ſaltem minuti promovebitur *Veneris* motus à parallaxi illa, interea dum *Solis* diſcum percurrit, in iis nempe Poli altitudinibus quæ Tropico vicinæ ſunt; atque adhuc amplius in vicinia Æquatoris. *Venus* autem tum temporis ſatis accurate quatuor minuta prima ſingulis horis intra *Solem* conficiet; ac propterea dodranti minuti undecim ſaltem temporis minuta prima competunt, quibus duratio *Eclipſeos* hujus *Venereæ* ob parallaxin contrahetur. Atque ex hac contractione ſolâ liceret de parallaxi quam quærimus tutò pronunciare, ſi modo darentur *Solis* diameter *Veneriſque* Latitudo in minimis accuratæ; quas tamen ad computum poſtulare, in re tam ſubtili, haud integrum eſt.

Procu-

Procuranda eſt ergo alia obſervatio, ſi fieri poſſit, in locis illis ubi medium *Solis* occupat *Venus* in ipſo Medinoctio; nempe ſub Meridiano priori oppoſito, *i. e.* ſex quaſi horis vel 90 gradibus *Londino* occidentaliore, & ubi *Venus* paulo ante occaſum *Solem* ſubintrat, paulo poſt ortum, exit; id quod fiet in dicto Meridiano, ſub altitudine Poli Borei quinquaginta ſex circiter graduum: hoc eſt, in eo Sinu qui *Hudſoni* dicitur, ad portum ejus cui nomen *Nelſoni*. In locis enim huic circumvicinis parallaxis *Veneris* durationem tranſitus protrahet, & ſex ſaltem temporis minutis longiorem efficiet; qui dum *Sol* ab occaſu in ortum ſub Polo tendere videtur, ea loca in diſco *Terræ*, motu contrario in occaſum ferri videbuntur, hoc eſt motu cum motu proprio *Veneris* conſpirante; proinde tardius moveri videbitur *Venus* intra *Solem*, ac cum diuturniore mora diſcum ejus pertranſire.

Si itaque in utroque loco hic tranſitus ab Obſervatoribus idoneis contigerit debitè obſervari, manifeſtum eſt totis ſeptendecim minutis longiorem futurum eſſe moram in portu *Nelſoni* obſervabilem, quam quæ apud *Indos* orientales expectanda eſt: nec magni intereſt, an ad Fortalitium *Sancti Georgii* vulgo *Maderas* dictum, vel ad *Bencoulam* in littore occiduo Inſulæ *Sumatræ* prope æquatorem capiatur obſervatio, ſi *Anglis* tum temporis hæc ſtudia curæ fuerint. Si vero *Gallis* his rebus invigilare placuerit, non incommode apud *Poudechery* ſe ſiſtet Obſervator in litore *Sinus Gangetici* occidentali, ſub altitudine Poli duodecim fere graduum. *Batavis* autem celeberrimum *Bataviæ* ſuæ Emporium Obſervatorium huic negotio ſatis commodum miniſtrat, ſi modo illis etiam animus fuerit hac in parte cœlorum ſcientiam promovere. Ac ſane vellem diverſis in locis ejuſdem Phænomeni obſervationes à pluribus inſtitui, tum ad majorem adſtruendam ex conſenſu fidem, tum ne Nubium interventu fruſtraretur ſingularis Spectator, eo ſpectaculo quod neſcio an denuo viſuri ſunt hujus & ſubſequentis ſeculi Mortales; & à quo pendet Problematis nobiliſſimi & aliunde inacceſſi ſolutio certa & adæquata. Curioſis igitur ſyderum ſcrutatoribus, quibus, hæc obſervanda reſervantur, iterum iterumque commendamus, ut moniti hujus noſtri memores, obſervationi peragendæ ſtrenuè totiſque viribus incumbant; iiſque fauſta omnia exoptamus & vovemus, utque Orbium cœleſtium magnitudines intra arctiores limites coercitæ in eorum gloriam famamque ſempiternam cedant.

Diximus autem hac ratione Solis Parallaxin intra quingenteſimam ſui partem inveſtigari poſſe, id quod nonnullis mirum ſine dubio videbitur. Veruntamen ſi in utroque è locis nuper deſignatis accurata habebitur obſervatio; jam monſtravimus, totis ſeptendecim minutis differre inter ſe durationes *Eclipſeωn* harum *Venerearum*, ex Hypotheſi ſcilicet quod Solis parallaxis fuerit duodecim cum dimidio minutorum ſecundorum. Quod ſi major vel minor reperta fuerit ex obſervatione hæc differentia, in eadem fere ratione major vel minor erit Solis parallaxis. Cumque 17 minuta prima temporis competant duodecim ſecundis cum dimidio parallaxeos Solaris; pro unoquoque parallaxeos mi-

minuto ſecundo, orietur differentia pluſquam 80 ſecundorum minutorum temporis; adeoque ſi habeatur differentia hæc intra bina ſecunda vera & comprobata, intra quadrageſimam partem unius ſecundi minuti conſtabit quanta ſit Solis Parallaxis; ac proinde diſtantia ejus determinabitur intra quinteſimam ſui partem, ſaltem ſi parallaxis non minor reperiatur eâ quam ſuppoſuimus: quadragies enim duodecim cum dimidio fiunt quingenti.

Hactenus aſtronomice doctis ſatis ſuperque rem indicavi, quos etiam monitos velim, me in hoc argumento, Latitudinis Planetæ rationem non habuiſſe, tum ad vitandas calculi intricatioris moleſtias, concluſionem etiam minus evidentem reddituras; tum ob motum Nodorum *Veneris* nondum compertum, nec niſi ex hujuſmodi corporalibus Planetæ cum *Sole* Conjunctionibus rite determinandum. Non enim concluſum eſt, *Venerem* quatuor minuta infra *Solis* centrum tranſituram, niſi ex Hypotheſi quod Planum Orbitæ *Veneris*, in Sphæra Stellarum fixarum immobile, Nodos ſuos iiſdem in locis habiturum ſit, ubi anno 1639. inventi ſunt. Quod ſi ſemita Auſtraliori tranſeat anno 1761, liquido patebit Nodos regredi; ſi vero Borealiori, progredi inter Fixas; idque in ratione $5\frac{1}{2}$ *min.* in centum annis *Julianis*, pro unoquoque minuto, quo via *Veneris* tum temporis plus vel minus diſtabit à *Solis* centro quam dictis quatuor minutis. Differentia autem inter durationes harum Eclipſium paulò minor erit ſeptendecim minutis, ob Latitudinem *Veneris* Auſtralem; major vero futura, ſi, procedentibus Nodis, ad Boream centri *Solem* tranſierit.

In eorum autem gratiam, qui cum obſervandis ſyderibus oblectentur, nondum tamen integram Parallaxium doctrinam hauſerint, libet *Schemate*, ſimulque Calculo paulo accuratiore, rem fuſius exponere.

Ponamus igitur anno 1761, *Maii* 25°. 17ʰ. 55′. *Londini*, *Solem* occupaturum ♊ 15°. 37′. ac proinde ad centrum ejus Eclipticam tendere in Boream angulo 60°. 10′. *Veneris* autem viſibilem intra *Solis* diſcum Viam tum temporis deſcendere in Auſtrum, facto angulo cum Ecliptica 8°. 28′: proinde via *Veneris* tendet parum in Auſtrum reſpectu æquatoris, interſecans declinationis parallelos angulo 2°. 18′. Ponamus etiam *Venerem* ad idem tempus *Solis* centro proximam fore, ac ab eodem quatuor minutis diſtare ad Auſtrum; ſinguliſque horis etiam quatuor minuta prima intra *Solem* motu retrogrado percurrere. Erit autem *Solis* Semidiameter 15′. 51″. proxime, *Veneris* vero 0′. $37''\frac{1}{2}$. Ac ſupponamus, experimenti gratia, differentiam parallaxium Horizontalium *Veneris* & *Solis*, quam quærimus, 0′. 31″ eſſe, qualis ex ſuppoſita *Solis* Parallaxi 0′. $12''\frac{1}{2}$ elicitur. Deſcribatur itaque centro *C* circellus *A E B D*, cujus ſemi-diameter ſit 0′. 31″. diſcum Terræ repræſentans, & in eo Ellipſes parallelorum 22 & 56 *grad.* Latitudinis Borealis, modo jam ad conſtruendas Eclipſes Solares ab Aſtronomis uſitato, ut *D a b E*, *c d e*: ſit autem *B C A* Meridianus in quo *Sol*; ad quem inclinetur recta *F H G* Viam *Veneris* deſignans angulo 2°. 18′, cujus diſtantia ſit à centro *C* 240 partium qualium *B C* eſt 31; & de *C* cadat recta Fig. 93.

CH ipſi FG perpendicularis. Ac poſito planeta in H ad $17^h.\ 55'$, vel $5^h.\ 55'$. mane, dividatur recta FHG in ſpatia Horaria III. IV, IV. V, V. VI, *&c.* ipſi CH, hoc eſt quatuor minutis æqualia. Fiat etiam recta KL, æqualis differentiæ apparentium Semidiametrorum *Solis* & *Veneris* ſive $15'.\ 13''\frac{1}{2}$. Et circulus Radio KL, centro vero quolibet puncto intra circellum Diſci *Terræ* deſcriptus, occurret rectæ FG in puncto denotante horam quæ *Londini* numerabitur, cum in eo *Terræ* ſuperficiei loco, qui ſumpto in diſco puncto ſubjacet, *Venus* angulo contactus interioris *Solis* limbum continget. At ſi centro C radio KL deſcriptus circulus occurrat ipſi FG in punctis F & G erunt rectæ FH, $HG = 14'.\ 41''$, id quod percurrere videbitur Venus tribus horis cum 40 min. Cadet igitur F in $2^h.\ 15'$, *Londini*; G vero in $9^h\ 35'$ mane. Unde patet quod, ſi Terræ magnitudo, ob immenſam diſtantiam, quaſi in punctum evaneſceret; vel ſi motu diurno deſtituta *Solem* haberet eidem puncto C ſemper verticalem, Eclipſeos hujus Mora integra per ſeptem horas cum triente duraret. Terrâ autem interea motu motui *Veneris* contrario gyratâ per 110 *grad.* Longitudinis ſuæ, ac proinde contractâ dictæ moræ duratione, puta 12 min. proveniet ea $7^h.\ 8'.$ proximè, ſive 107 *grad.*

Jam in ipſo Meridiano *Venus Solis* centro proxima erit ad Oſtium orientale fluminis *Gangis*, ubi poli altitudo eſt 22 *grad.* circiter. Locus igitur ille utrinque æqualiter diſtabit à Sole, in momentis introitus & exitus planetæ, nempe $53°\frac{1}{2}$ *grad.* ut ſunt puncta a, b, in parallelo majore $DabE$. Erit autem Diameter AB ad diſtantiam ab ut quadratum Radii ad contentum ſub Sinubus $53\frac{1}{2}$ & 68° *grad.* hoc eſt, ut $1'.\ 02''$ ad $0'.\ 46''.\ 13'''$; ac calculo rite inſtituto (quem ne tædio ſit omitto) invenio quod circulus centro a & radio KL deſcriptus occurret rectæ FH, in puncto M, ad $2^h.\ 20'.\ 40''$; centro vero b deſcriptus occurret ipſi HG in N, ad $9^h.\ 29'.\ 22''$; horis ſcilicet *Londini* numeratis; proinde tota *Venus* intra *Solem* conſpicietur ad *Gangis* ripas, per $7^h.\ 8'.\ 42''$. Rectè igitur poſuimus durationem fore $7^h.\ 8'$; cum pars minuti hîc nullius ſit momenti.

Aptato autem calculo ad *Portum Nelſoni*, reperio quod Sole jamjam occaſuro, diſcum ejus ſubitura ſit Venus; ſtatim vero ab ortu ejus exitura ab eodem; Loco illo interea per Hemiſphærium à Sole averſum de c ad d tranſlato, motu motui *Veneris* conſpirante. Mora igitur *Veneris* intra *Solem* diuturnior fiet ob Parallaxin, puta quatuor minutis; ut ſit omnino $7^h.\ 24'.$ ſive 111 *grad.* æquatoris. Cumque Latitudo Loci ſit 56 *gr.* erit ut Quadratum Radii ad contentum ſub Sinubus $55\frac{1}{2}$ & 34 *grad.* ita $AB = 1'$, $02''$ ad $c\ d = 28''.\ 33'''$. Ac calculo rite exacto conſtabit, circulum centro c radio KL deſcriptum rectæ FH occurſurum in O, ad $2^h.\ 12'.\ 45''$, centro vero d deſcriptum ipſi HG in P, ad $9^h.\ 36'.\ 37''$. Unde duratio Moræ ad *Nelſoni* portum erit $7^h.\ 23'.\ 52''$; major ſcilicet quam ad oſtia *Gangis* totis $15'.\ 10''$ temporis. Quod ſi *Venus* abſque Latitudine tranſierit, fiet dicta differentia, $18'.\ 40''$; Si vero quatuor minutis *Solis* centro fuerit Borealior, ad $21'.\ 40''$ augebitur

gebitur eadem differentia, multo major futura auctâ Planetæ Latitudine Boreali.

Londini autem, ex prædictis Hypotheſibus, conſequitur *Venerem* jam tum infra *Solem* ingreſſam orituram; & ad $9^h.\ 37'.$ mane, in Egreſſu *Solis* limbum interius contacturam; ac denique non niſi horâ $9^h.\ 56'$, orbem ejus integrum relicturam eſſe.

Ex iiſdem etiam Hypotheſibus ſequitur *Venerem* extremum *Solis* limbum Boreum quaſi centro ſuo ſtringere debere, Anno 1769, *Maii* $23^o.\ 11^h.\ 00'$, ita ut, ob Parallaxin, in Borealibus *Norwegiæ* partibus, tota intra *Solem* inocciduum apparere poterit: dum in littoribus, *Peruviæ* & *Chili*, vix exiguo ſui ſegmento cadentis *Solis* diſco quaſi inequitare videbitur; uti in Inſulis *Moluccis* lociſque vicinis, oriente *Sole*. Quod ſi Nodi *Veneris* retrocedere reperiantur (ut ob nuperas quaſdam obſervationes ſuſpicio eſt) tum toto corpore intra orbem *Solis* ubique conſpicua, maximâ harum Eclipſeων differentiâ argumentum Parallaxeos *Solaris* præbebit adhuc multo luculentius.

Quomodo autem ex obſervatis alicubi apud *Indos* Orientales, anno 1761. Ingreſſu & Egreſſu *Veneris*, & cum Exitu ejus apud Nos obſervabili collatis, eadem Parallaxis derivari poterit; aptando ſcilicet angulos Trianguli ſpecie dati in trium Circulorum æqualium circumferentias, alia occaſione docebitur.

IV. *Keplero* Inventori debetur ea, quâ nunc utimur, Theoria, nempe quod Corpora cæleſtia Solem ambiunt in communi orbium Ellipticorum Foco ſitum, ea lege ut Areæ Temporibus proportionales radiis ad Solem ductis deſcribantur. Sublimiorem vero poſtulat Geometriam, ad oſtendendum quam ob cauſam hoc ita ſe habeat, quodque aliter eſſe non poſſit. Hoc in celeberrimi D. *Newtoni* gloriam reſervatum eſt. *Of the* Maxima, *and* Minima *in the Motions of the* Cœleſtial *Bodies, by* .... n. 360. p. 948.

Hujus veſtigiis inſiſtens, Corollaria quædam exhibuit eximius Mathematicus † D. *Abr. de Moivre* R. S. S. Theoremata ſcil. parata, quibus determinantur Velocitates ſive Momenta Motûs tam veri quam apparentis circa Solem, ſicut etiam acceſsûs vel receſsûs à Sole, in dato quovis datorum Orbium puncto. Deinde ut Theoriam ſyſtematis Planetici ulterius excoleret, ope eorundem Theorematum, dictorum Momentorum Momenta perſcrutatus eſt, oſtenditque quibus in orbium punctis fiant *Maximæ* harum Velocitatum mutationes, idque Solutionibus facilitate & concinnitate præſtantibus. † *Vid.* ſupra C. I. S. II.

Sit ABP Orbis Planetæ ellipticus, AP Axis tranſverſus, CB Semiaxis conjugatus, S Sol, Q Focus alter Ellipſeos. Per S ducatur SM ipſi CB parallela: & erit punctum M in quo *Maxima* cum velocitate augetur vel minuitur diſtantia à Sole, $SM = AC - \frac{SC}{AC}$. Fig. 94.

Si vero capiatur SL media proportionalis inter Semiaxes AC, CB erit punctum L in quo *Maxima* fit æquatio Centri, ut vocant; ſive ubi motus angularis fit æqualis medio Motui: Quod ſi Eccentricitas non excedat illam quam pleræque Planetæ obtinent, $BL = \frac{1}{4} BM$ quam proximè: Eſt vero $SL = \sqrt{\sqrt{AC^4 - AC^2 SC^2}}$.

Si quæratur punctum N, in quo fit *Maxima* mutatio Velocitatis motûs realis in Curvâ, Problema ſolidum eſt. Eſt enim $2NS = 4AC - 2NQ$ ad $3NQ - AC$ ut $AC^2 - CS^2 = CB^2$ ad NQ: adeoque ſi ponatur $AC = a$, $CB = c$ & $NQ = y$, habebitur æquatio $y^3 - 2ayy + \frac{1}{2}ccy - \frac{1}{2}acc = 0$. Quâ reſolutâ erit y ſive NQ diſtantia puncti quæſiti N ab altero Ellipſeos foco. In Orbibus vero parum Eccentricis, quales ſunt Planetarum, ſi fiat $CD = SQ$, & junctæ AD æqualis ponatur AK, erit reliqua pars Axis $KP = NS$ diſtantia puncti N à Sole quam proxime. Si vero Orbis fuerit Parabolica erit SN ad SP ut 5 ad 4, anguluſque NSP erit 53°. 8′ fere, cujus Sinus eſt $\frac{4}{5}$ Radii.

At punctum O, in quo motûs apparentis ſive angularis acceleratio Planetæ deſcendentis, vel retardatio aſcendentis *Maxima* fit, hoc modo habebitur. In AC capiatur $GC = \frac{1}{6}AC$, ac fiat angulus CSF 30 *gr.* ductæque SF æqualis ponatur CE, ipſique GE ſit GH æqualis. Dico, ſi diſtantia SO fiat æqualis ipſi PH, quod in puncto O proveniet *Maxima* mutatio motus angularis Planetæ in Orbe Elliptico $ABOP$ moventis; eo ſcilicet in Orbis loco ſecundæ differentiæ æquationum centri Planetæ reperientur *Maximæ*. Eſt autem $SO = \frac{7}{6}AC - \sqrt{\frac{1}{36}AC^2 + \frac{1}{3}SQ^2}$. Quod ſi Orbis Parabolica fuerit, ut in Cometis, fiet SO ad SP ut 8 ad 7. anguluſque OSP fiet 41°. $24'\frac{1}{2}$, ſive cujus Sinus ſit ad Radium ut $\frac{1}{4}\sqrt{7}$ ad 1.

Denique *Minimâ* cum Velocitate mutatur directio Tangentis Orbitæ in puncto R, ſi fiat SR æqualis duabus tertiis Axis majoris AB. Quod ſi Eccentricitas SC minor fuerit quam $\frac{1}{3}PC$, *Minimum* hoc non locum habet, ſed decreſcit ſemper hæc Velocitas quâcum revolvitur Tangens, uſque in ipſum Aphelion quemadmodum eſt in omnium Planetarum motibus. Neque etiam in orbe Parabolico obtinet, ob Axem ejus in infinitum protenſum.

Hæc omnia demonſtrantur, juxta præcepta Doctrinæ de *Maximis* & *Minimis*, ex Theorematibus prædictis D. *Abr. de Moivre*.

A new Star in Collo Cygni, *by Mr.* G. Kirch, n. 343. p. 226. *Miſcel. Berolin.* p. 208.

V. Quanquam multæ varietates mutationeſque inter Stellas fixas, quoad apparentem earum magnitudinem, in cœlo contingant, nulla tamen inter omnes mutabilis apparentiæ Stellas fixas mirabilior habita eſt, illâ quam *Fabricius* Anno 1596. in *collo Ceti* primus obſervavit. Licet enim primò pro ejuſmodi nova Stella habita fuerit, quæ nunquam antea extiterit, & poſtquam diſparuit non amplius eſſet reditura: nunc tamen experientia ſatis comprobavit eam conſtanter exiſtere, & abſque omni dubio à principio mundi in eo loco, quem nunc quoque obtinet, exſtitiſſe. Hoc ſolummodo in ea mirandum, quod ſeſe quotannis in

variâ magnitudine ſpectandam exhibeat, & plerumque certis temporibus nudis oculis plane videri nequeat; qua de cauſa etiam a Domino *Hevelio* Stella Mira vocata eſt.

Aliam huic ſimilem ego quoque in *collo Cygni* deprehendi, multo autem minorem, & quotannis breviori ſpatio temporis conſpiciendam. Unde mirum non eſt eam tamdiu incognitam manſiſſe: Imo pro ſingulari felicitate reputandum, quod eo ipſo tempore viſibilis fuerit, ac in ſua maxima magnitudine apparuerit, quo *Bayerus* Stellas in Cygno conſiderabat & delineabat, ubi eam notâ χ deſignavit, & inter conſtanter apparentes fixas $5^{tæ}$ magnitudinis recenſuit: quemadmodum etiam ſupra memoratam in collo Ceti, cum hocce Sydus conſideraret & delinearet, in quarta magnitudine deprehendit & literâ o deſignavit, eamque pro conſtanter apparente Stella fixa habuit. Fig. 95.

Ut mutabilem apparentiam Stellæ χ in collo Cygni deprehenderem, occaſionem dedit Stella capiti Cygni vicina, quam *Hevelius* Anno 1670 & 71. obſervavit. Cum enim ſpem conciperem fore ut eadem Stella nunc iterum ſæpius eſſet apparitura, non ſecus ac Stella in *collo Ceti*, quam *Hevelio* poſt primam diſparitionem mox iterum apparuiſſe conſtabat, quærebam eam 1^{o} & 6^{to} (11^{o} & 16^{o}) *Julii* 1686. noctibus ſerenis, non autem reperiebam; ſed potius animadvertebam Stellam illam $5^{tæ}$ magnitudinis in collo Cygni, à *Bayero* græca litera χ ſignatam, deſiderari. Die vero 9^{o} (19.) *Octobris* deprehendi eam nudis oculis diſtinctè omnino. Et quia facile adducebar ut exiſtimarem eandem nudis noſtris oculis iterum diſparituram, delineavi aliquot ipſam circumſtantes Stellulas, ope bipedalis magnæque capacitatis Tubi, ut ex harum cum illa comparatione magnitudinem ejus, cum decreſceret, expenderem, uti *Fig. A* exhibetur. Fig. 96.

Deprehenſum eſt quoque, Stellam iſtam paulatim decreviſſe, donec eam Tubo 8 pedum non potuerim amplius aſſequi, cum tamen aliam in *collo Ceti*, quando nudo oculo non amplius patet, per Tubum 4 pedum ſemper dignoſcere poſſim.

Ab illo tempore quærebam quidem Stellam iſtam variis noctibus fruſtra, tandem verò tamen eam reperi 6^{to} (16^{o}) *Aug.* 1687. iterum ope octopedalis Tubi, at vero exiguam valde. Inde de die in diem creviſſe deprehendebatur; & factum eſt, ut die 23 *Octob.* (2 *Novemb.*) iterum primâ vice nudo oculo ſeſe conſpiciendam præberet, valde licet adhuc dum exiguam. Die 2^{do} (12^{o}) *Nov.* optime erat conſpicua, etiam poſt 26^{tum}. *Nov.* (6. *Dec.*) ut ut hoc ultimo die jam iterum in ſtatu decreſcendi exiſteret. Poſtmodum non niſi per Tubos dignoſci potuit, tandemque adeo exigua evaſit, ut iterum Tubo 8 pedum eam deprehendere non potuerim. Atque ita animadverſum eſt hac vice, ab una diſparitione uſque ad alteram, annum unum, menſem unum unamque hebdomadam circiter effluxiſſe. Sequentes quoque obſervationes docuerunt hancce Stellam tempus ſatis conſtans in ſua apparitione ſervare, non tamen quavis vice ad æqualem magnitudinem pervenire. Imo aliquando accidit, ut nudo oculo planè inviſibilis maneat, dum per Tubum eſt conſpicua & maximam ſuam magnitudinem aſſecuta eſt; prout Anno 1688 in fine, & 1689.

in principio anni accidit. E contrario, ſequente anni 1690, ſtella hæc eo melius videri poterat, & quidem notabiliter major quam ſua vicina, quam *Bayerus* juxta χ collocavit extra collum Cygni, nullâque literâ notavit; quam ego ſolius memoriæ juvandæ gratia Hebraica litera ג notavi. Et poſtquam hujus ſtellæ apparentiam ſæpius obſervavi, comperi eam valde eſſe regularem revolutionemque $404\frac{1}{2}$ dierum ſervare.

Cum Miſcellanea Berolinenſia *ſerius ad nos perlata ſint, non ante annum ultimo elapſum hanc Stellam novam ſecundum D.* Kirchii *monitum conſpeximus; idque juxta Idus Julii,* ſt. vet. *cum multo clarior quam vicina* ג, *ac fere æqualis mediæ in collo Cygni* (Bayero η) *apparuit: ſed poſt menſem nudis oculis inconſpicua facta, tandem etiam Teleſcopio evanuit. Juxta periodum qua revolvi dicitur, menſe ſaltem Auguſti currentis anni* 1715. *maximam ſuam claritatem adipiſci debet.*

Fig. 95. *Ut autem facilius in Cælo inveniatur, duo* Schemata *adjecimus, quorum* alterum *exhibet* Cygni collum, *cum Fixis huic Novæ adjunctis, Noviſque duabus aliis intra ſeculum in ejus vicinia emerſis; quarum quæ ante* Pectus Cygni *etiamnum conſpicitur quaſi quinti honoris: quæ vero ſub Capite per*

Fig. 96. *biennium tantum viſa hactenus latet. Altera* Figura, *quæ eſt* Kirchii A, *Teleſcopicas Novæ proximas demonſtrat, ut ſciatur quo præciſe loco primum redeuntis radium ſeduli Cæliſpices Tubo armati præſtolari debeant.*

A Hiſtory of the new *Stars for the laſt* 150 *Years, by* .... n. 346. p. 354.

VI. Although it be ſaid that *Hipparchus*, on occaſion of a new Star that appeared in his Time, was induced to number the Stars, and make the firſt Catalogue of them, which was, in the Opinion of *Pliny*, *Res vel Deo improba*; yet neither he nor any of the Ancients have left us the Place of that new Sta , to compare with thoſe lately ſeen, one of which might perhaps be the ſame with it, re-appearing after a long Period of Years. Now though ſeveral Authors have ſeverally deſcribed thoſe that have been ſeen nearer to our Times, it may not be amiſs to give a ſhort Recapitulation of what was principally remarkable in each of them, with the Times of their firſt Appearance, as far as can be collected.

And firſt, That in the *Chair* of *Caſſiopeia*, was not ſeen by *Cornelius Gemma* on the Eighth of *November* 1572, who ſays, he that Night conſidered that Part of Heaven in a very ſerene Sky, and ſaw it not: but that the next Night, *November* 9°, it appeared with a Splendour exceeding all the fixt Stars, and ſcarce leſs bright than *Venus*. This was not ſeen by *Tycho Brahe* before the 11th of the ſame Month, but from thence He aſſures us, that it gradually decreaſed and died away, ſo as in *March* 1574, after ſixteen Months, to be no longer viſible; and at this Day not the leaſt Signs of it remain. The Place thereof in the Sphere of fixt Stars, by the accurate Obſervations of the ſame *Tycho*, was 0ˢ. 9°. 17′. *à* 1ma ✱ ♈is, with 53°. 45′. North Latitude.

Such

Such another Star was ſeen and obſerved by the Scholars of *Kepler*, to begin to appear on *Sept.* 30°. *ſt. vet. anno* 1640, which was not to be ſeen the Day before: but it broke out at once with a Luſtre greater than that of *Jupiter*; and like the former it died away gradually, and in much about the ſame time diſappeared totally, there remaining no Footſteps thereof in *January* 160$\frac{4}{6}$. This was near the Ecliptick, following the Right-Leg of *Serpentarius*; and by the Obſervations of *Kepler* and others, was in 7^{s}. 20°. 00′ à 1ma ✱. ♈, with North Latitude 1°. 56′. Theſe two ſeem to be of a diſtinct *Species* from the reſt, and nothing like them has appeared ſince.

In the Year 1596, we have the firſt Account of the wonderful Star *in Collo Ceti*, ſeen by *David Fabricius* on the third of *Auguſt. ſt. vet.* as bright as a Star of the third Magnitude, which has been ſince found to appear and diſappear periodically: its Period being preciſely enough 7 Revolutions in ſix Years, though it return not always with the ſame Luſtre. Nor is it ever intirely extinguiſhed, but may at all times be ſeen with a Six-foot Tube. This was ſingular in its Kind, till that in *Collo Cygni* was diſcovered. It precedes the firſt Star of *Aries* 1°. 40′, with 15°. 57′ South Latitude.

Another new Star was firſt obſerved by *Will. Janſonius* in 1600, *in Pectore* or rather *in eductione Colli Cygni*, which exceeded not the third Magnitude. This Star having continued ſome Years, became at length ſo ſmall as to be thought by ſome to diſappear intirely: but in the Years 1657, 58, and 59, it again aroſe to the third Magnitude, though ſoon after it decayed by degrees to the fifth or ſixth Magnitude, and at this Day is to be ſeen as ſuch in 9^{s}. 18°. 38′. *à* 1ma ✱. ♈, with 55°. 29′. North Latitude.

A fifth new Star was firſt obſerved by *Hevelius* in 1670, on *July* 15. *ſt. vet.* as a Star of the third Magnitude, but by the Beginning of *October* was ſcarce to be perceived by the naked Eye. In *April* following it was again as bright as before, or rather greater than of the third Magnitude, yet wholly diſappeared about the middle of *Auguſt*. The next Year, in *March* 1672. it was ſeen again, not exceeding the ſixth Magnitude: ſince when it has been no farther viſible, though we have frequently ſought for its Return; its place is 9^{s}. 3°. 17′. *à* 1ma ✱. ♈. and has Lat. North, 47°. 28′.

A Return of the new *Star* in Collo Cygni.

The ſixth and laſt is that we deſcribed before from the *Acta Berolinenſia*, diſcovered by Mr. *G. Kirch* in the Year 1686, and its Period determined to be of 404$\frac{1}{2}$ Days: and though it rarely exceed the fifth Magnitude, yet is it very regular in its Returns, as we have found in the Year 1714. Since then we have endeavoured, as the Abſence of the Moon and the Clearneſs of Weather would permit, to catch the firſt Beginning of its Appearance in a Six-Foot Tube, that bearing a very great Aperture diſcovers moſt minute Stars. And on *June* 15. laſt, it was firſt perceived like one of the very leaſt Teleſcopical Stars; but in the reſt of that Month and *July* it gradually increaſed,

Vid. ſupra. §. V.

ſo as to become in *Auguſt* viſible to the naked Eye; and ſo it continued all the Month of *September*. After that it again died away gradually, and on the 8th of *December* at Night was ſcarce diſcernible by the Tube, and as near as could be gueſſed, equal to what it was at its firſt Appearance on *June* the 15th: ſo that this Year it has been ſeen in all near ſix Months, which is but little leſs than half its Period: and the middle, and conſequently the greateſt Brightneſs, falls about the 10th of *September*. Thoſe that pleaſe to ſeek for it, may expect its firſt Appearance in *July* next, and find it in 9s. 6°. 30′. *circiter à* 1ma ✱. ♈, with *Lat. Bor.* 52°. 40′.

Lucid Spots or Nebulæ, *amongſt the fixt Stars, by* ..... n. 347. p. 390.

VII. Wonderful are certain luminous Spots or Patches, which diſcover themſelves only by the Teleſcope, and appear to the naked Eye like ſmall fixt Stars; but in reality are nothing elſe but the Light coming from an extraordinary great Space in the Æther; through which a lucid *Medium* is diffuſed, that ſhines with its own proper Luſtre. This ſeems fully to reconcile that Difficulty which ſome have raiſed againſt the Deſcription *Moſes* gives of the Creation, alledging that Light could not be created without the Sun. But in the following Inſtances the contrary is manifeſt; for ſome of theſe bright Spots diſcover no Sign of a Star in the middle of them; and the irregular Form of thoſe that have, ſhews them not to proceed from the Illumination of a central Body. Theſe are ſix in Number, all which we will deſcribe in the Order of Time, as they were diſcovered, giving alſo their Places in the Sphere of fixt Stars.

The firſt and moſt conſiderable is that in the middle of *Orion*'s Sword, marked with θ by *Bayer* in his *Uranometria*, as a ſingle Star of the third Magnitude; and is ſo accounted by *Ptolomy*, *Tycho Brahe* and *Hevelius*: but is in reality two very contiguous Stars environed with a very large tranſparent bright Spot, through which they appear with ſeveral others. Theſe are curiouſly deſcribed by *Hugenius* in his *Syſtema Saturnium*, pag. 8.. who there calls this Brightneſs, *Portentum, cui certe ſimile aliud nuſquam apud reliquas Fixas potuit animadvertere:* affirming that he found it accidentally in the Year 1656. The middle of this is at preſent in ♊ 19°. 00′, with South Lat. 28° ¾.

About the Year 1661. another of this Sort was diſcovered (if I miſtake not) by *Bullialdus*, *in Cingulo Andromedæ*. This is neither in *Tycho* nor *Bayer*, having been omitted, as are many others, becauſe of its ſmallneſs: But it is inſerted into the Catalogue of *Hevelius*, who has improperly called it *Nebuloſa* inſtead of *Nebula*; it has no Sign of a Star in it, but appears like a pale Cloud, and ſeems to ſend forth a radiant Beam into the North Eaſt, as that in *Orion* does into the South Eaſt. It proceeds in Right Aſcenſion the Northern in the Girdle, or ν *Bayero*, about a Degree and three Quarters, and has Longitude at this time ♈. 24°. 00′ with Lat. North 33° ⅓.

The

The third is near the Ecliptick between the *Head* and *Bow* of *Sagittary*, not far from the Point of the Winter Solſtice. This was found in the Year 1665, by a *German* Gentleman *M. J. Abraham Ihle*, while he attended the Motion of *Saturn* then near his *Aphelion*. This is ſmall but very luminous, and emits a Ray like the former. Its Place at this time is ♑ $4°\frac{1}{2}$ with about half a Degree South Lat.

A fourth was diſcovered by M. *Edmund Halley* in the Year 1677, when he was making the Catalogue of the Southern Stars. It is in the *Centaur*, that which *Ptolomy* calls ὁ ἐπὶ τῆς τῶ νώτῳ ἐκφύσεως, which he names *in dorſo Equino Nebula* and is *Bayer*'s ω; It is in Appearance between the fourth and fifth Magnitude, and emits but a ſmall Light for its Breadth, and is without a radiant Beam; this never riſes in *England*, but at this time its Place is ♏ $5°\frac{1}{4}$ with $35°\frac{1}{3}$ South Latitude.

A fifth was diſcovered by Mr. *G. Kirch* in 1681, preceding the Right Foot of *Antinous:* It is of itſelf but a ſmall obſcure Spot, but has a Star that ſhines through it, which makes it more bright. The Longitude of this is at preſent ♑. 9°. *circiter*, with $17°\frac{1}{6}$. North Latitude.

The ſixth and laſt was accidentally hit upon by M. *Edmund Halley* in the Conſtellation of *Hercules*, in the Year 1714. It is nearly in a Right Line with ζ and η of *Bayer*, ſomewhat nearer to ζ than η: and by comparing its Situation among the Stars, its Place is ſufficiently near in ♏ $26°\frac{1}{2}$. with 57°. 00. North Lat. This is but a little Patch, but it ſhews itſelf to the naked Eye, when the Sky is clear, and the Moon abſent.

There are undoubtedly more of theſe, which have not yet come to our Knowledge, and ſome perhaps bigger, but though all theſe Spots are in Appearance but ſmall, and moſt of them but of few Minutes in Diameter; yet ſince they are among the fixt Stars, that is, ſince they have no annual Parallax, they cannot fail to occupy Spaces immenſely great, and perhaps not leſs than our whole Solar Syſtem. In all theſe ſo vaſt Spaces it ſhould ſeem, that there is a perpetual uninterrupted Day, which may furniſh Matter of Speculation, as well to the curious Naturaliſt as to the Aſtronomer.

VIII. I have compared the Declinations of the fixt Stars delivered by *Ptolomy*, in the 3d Chapter of the 7th Book of his *Almag.* as obſerved by *Timocharis* and *Ariſtyllus* near 300 Years before *Chriſt*, and by *Hipparchus* about 170 Years after them, that is about 130 Years before *Chriſt*, with what we now find: and by the Reſult of many Calculations, I concluded that the fixt Stars in 1800 Years were advanced ſomewhat more than 25 Degrees in Longitude, or that the Preceſſion is ſomewhat more than 50″ *per annum*. But that with ſo much uncertainty, becauſe of the imperfect Obſervations of the Ancients, that I have choſen in my Tables to adhere to the even

Change *of the* Latitudes *of ſome of the* fixt Stars, *by Dr.* E. Halley, n. 355. p. 736.

Proportion of five Minutes in ſix Years, which from other Principles we are aſſured is very near the Truth. But while I was upon this Enquiry, I was ſurprized to find the Latitudes of three of the principal Stars in the Heaven directly to contradict the ſuppoſed greater *Obliquity* of the *Ecliptick*, which ſeems confirmed by the Latitudes of moſt of the reſt; they being ſet down in the old Catalogue, as if the Plane of the Earth's Orb had changed its Situation, among the fixt Stars, about 20′ ſince the Time of *Hipparchus*. Particularly all the Stars in *Gemini* are put down, thoſe to the *Northward* of the Ecliptick with ſo much leſs Latitude than we find, and thoſe to the *Southward* with ſo much more *Southerly* Latitude. And yet the three Stars *Palilicium* or the *Bull's* Eye, *Sirius* and *Arcturus* do contradict this Rule: for by it, *Palilicium*, being in the Days of *Hipparchus* in about 10 *gr.* of *Taurus*, ought to be about 15 Min. more *Southerly* than at preſent; and *Sirius* being then in about 15 of *Gemini* ought to be 20 Min. more *Southerly* than now; yet *Ptolemy* places the firſt 20 Min. and the other 22 more *Northerly* in Latitude than we now find them. Nor are theſe the Errors of Tranſcribers, but are proved to be right by the Declinations of them ſet down by *Ptolomy*, as obſerved by *Timocharis*, *Hipparchus* and himſelf, which ſhew that thoſe Latitudes are the ſame as thoſe Authors intended. As to *Arcturus*, he is too near the Equinoctial Colure, to argue from him concerning the Change of the Obliquity of the Ecliptick, but *Ptolomy* gives him 33′ more *North* Latitude than he now is found to have; and that greater Latitude is likewiſe confirmed by the Declinations delivered by the aboveſaid Obſervers. So then theſe three Stars are found to be above half a Degree more *Southerly* at this time, than the Ancients reckoned them. When on the contrary at the ſame time the bright Shoulder of *Orion* has in *Ptolomy* almoſt a Degree more *Southerly* Latitude than at preſent. What ſhall we ſay then? It is ſcarce to be believed, that the Ancients could be deceived in ſo plain a Matter, three Obſervers confirming each other. Again theſe Stars being the moſt conſpicuous in Heaven, are in all probability the neareſt to the Earth; and if they have any particular Motion of their own, it is moſt likely to be perceived in them, which in ſo long a Time as 1800 Years may ſhew itſelf by the Alteration of their Places, though it be intirely imperceptible in the Space of one ſingle Century of Years. Yet as to *Sirius* it may be obſerved, that *Tycho Brahe* makes him 2 Min. more *Northerly* than we now find him, whereas he ought to be above as much more *Southerly* from his Ecliptick, (whoſe Obliquity he makes $2\frac{1}{2}$ greater than we eſteem it at preſent) differing in the whole $4\frac{1}{2}$ Min. One half of this Difference may perhaps be excuſed, if Refraction were not allowed in this Caſe by *Tycho*; yet two Minutes, in ſuch a Star as *Sirius*, is ſomewhat too much for him to be miſtaken.

But a more evident Proof of this Change is drawn from the Obſervation of the Application of the Moon to *Palilicium*, *Anno Chriſti* 509

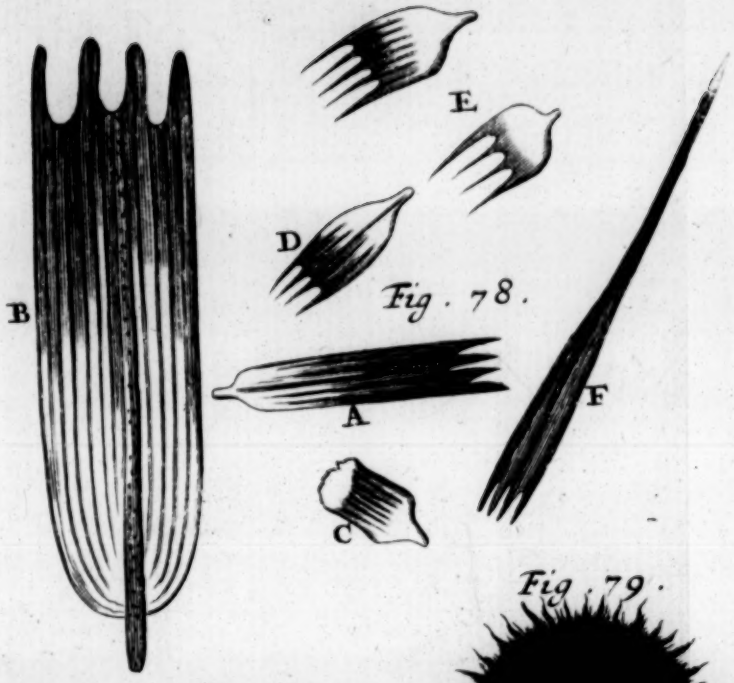


Fig. 78.

Fig. 79.

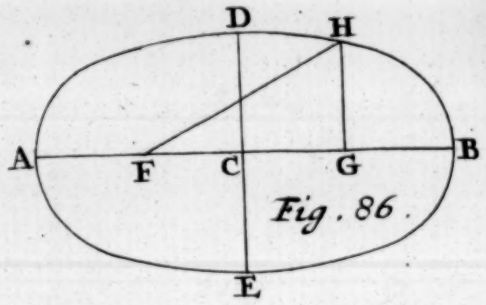


Fig. 86.

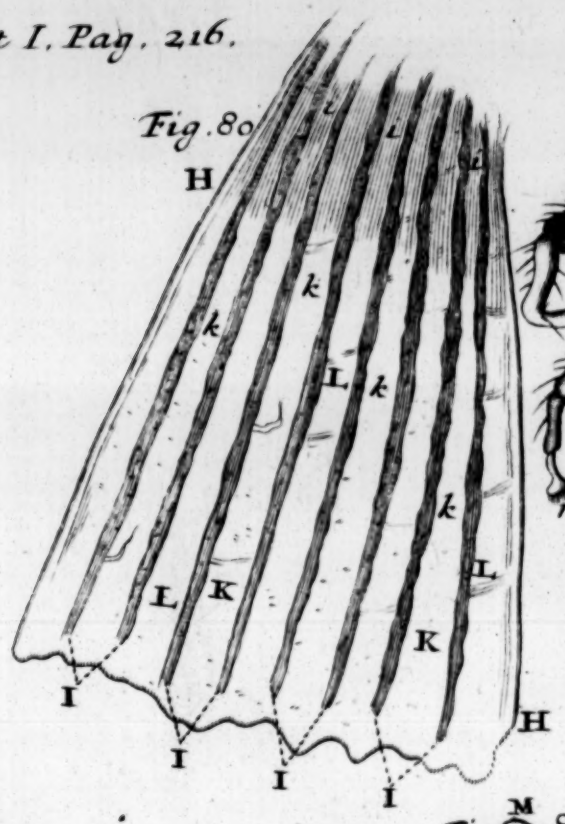


Fig. 80.

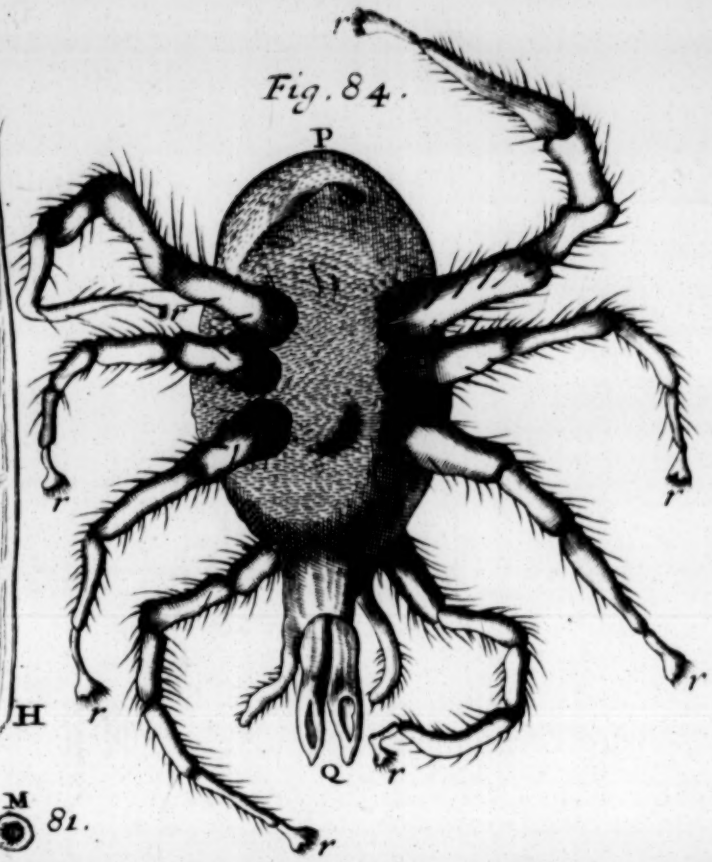


Fig. 84.

Fig. 81.

Fig. 83.

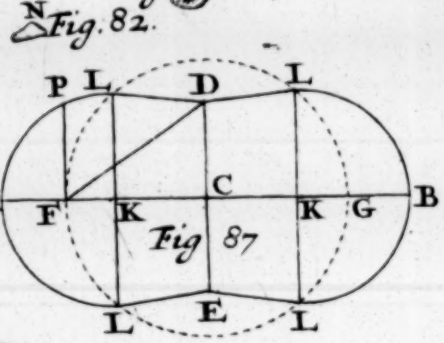


Fig. 82.

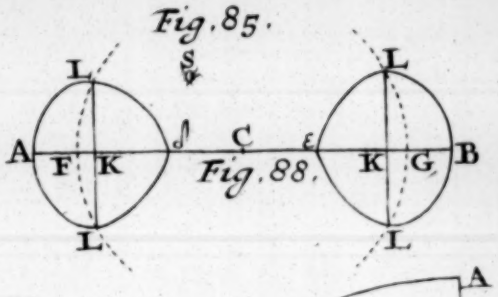


Fig. 85.

Fig. 87.

Fig. 88.

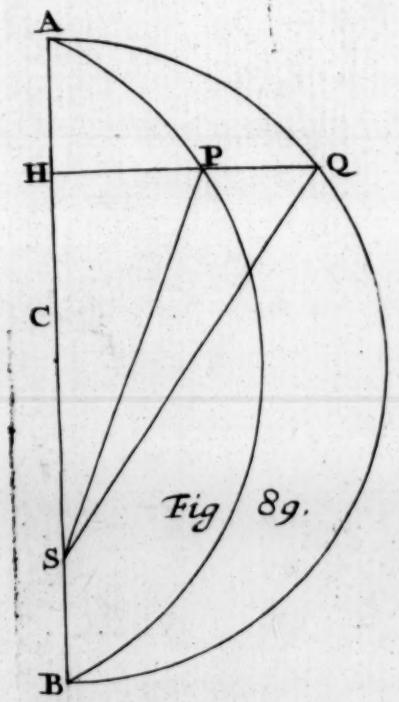


Fig. 89.

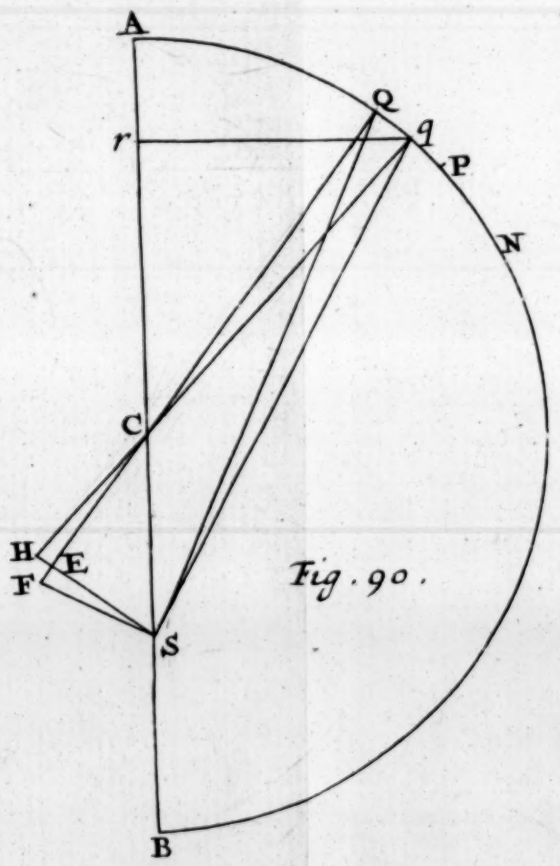


Fig. 90.

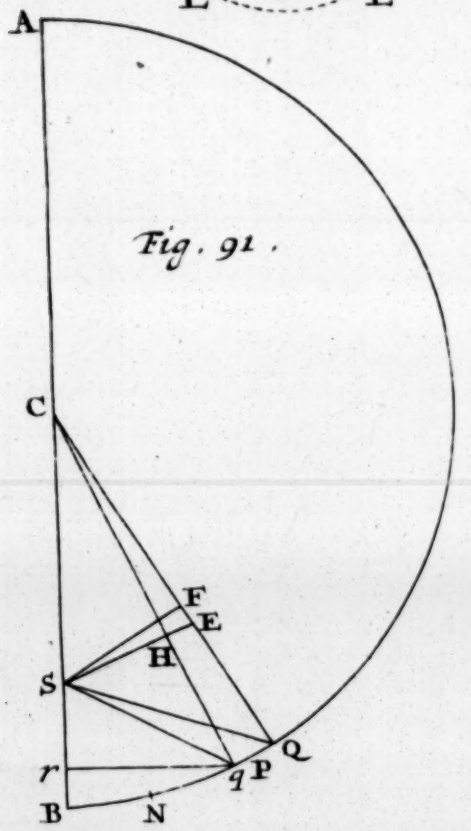


Fig. 91.

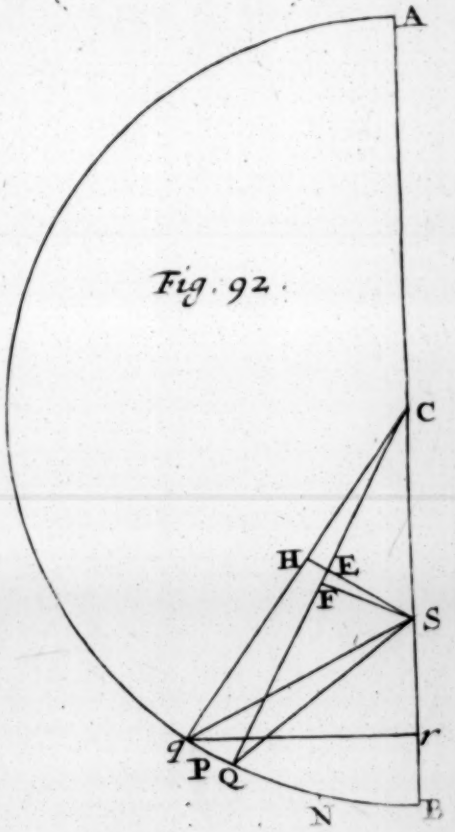


Fig. 92.

Mart. 11°. when in the beginning of the Night the Moon was ſeen to follow that Star very near, and ſeemed to have eclipſed it, ἐπέβαλλε γὰρ ὁ ἀστὴρ τῷ κατὰ τὴν διχοτομίαν μέρει τῆς κύρτης περιφερείας τὸ πεφωτισμένον μέρος, i. e. *Stella appoſita erat parti per quam biſecabatur limbus Lunæ illuminatus*, as *Bullialdus*, to whom we are beholden for this ancient Obſervation, has tranſlated it. Now, from the undoubted Principles of Aſtronomy, this could never be true at *Athens*, near it, unleſs the Latitude of *Palilicium* were much leſs than we at this time find it. *Vide Bullialdi Aſtr. Philolaica*, pag. 172.

This Argument ſeems not unworthy of the *Royal Society*'s Conſideration, to whom I offer the Plain Fact as I find it, and would be glad to have their Opinion.

But whether it were really true, that the Obliquity of the Ecliptick was, in the time of *Hipparchus* and *Ptolomy*, really 22 Min. greater than now, may well be queſtioned; ſince *Pappus Alexandrinus*, who lived but about 200 Years after *Ptolomy*, makes it the very ſame that we do. *Vide Pappi Collect. Lib.* VI. *Prop.* 35.

Mock-Suns, *and Circular Arches, ſeen, by Mr.* E. Halley, n. 278. p. 1127.

IX. On the Eighth of *April*, 1702, walking in *London* Streets about ten in the Morning, the Air being clear, I obſerved the Sun to ſhine faintly, or as we call it wateriſh; whereupon caſting up my Eye, I perceived ſeveral Arches of Circles about him. I made what haſte I could to get on the Top of a Houſe, which I did at Mr. *Mordens* by the *Royal-Exchange*, and found the Appearance as is deſcribed *Figure* 97. wherein

Fig. 97.

S is the true Sun, *Z* the Zenith.

S T P P a great wide Circle paſſing through the Sun, and as well as I could judge, parallel to the Horizon. It was very diſtinct and entire, about two Degrees broad in the *Northern* Part about *T*; and held much the ſame breadth in the *Eaſt* and *Weſt*, but grew narrower towards the Sun; its Edges were not very well defined, the whole appearing like a faint white Cloud, and a Part of it would have been taken for ſuch, but the whole Circle ſeen in the pure Azure Sky was a very ſurprizing Sight.

V N X Y a *Halo*, or rather *Iris*, that was likewiſe an intire Circle, having the Sun for its Center. I meaſured the Semidiameter of this to be much about 22 Degrees: the Breadth of this Arch which was well defined, was by Eſtimate equal to the Sun's Diameter, and it was coloured with the Colours of the *Iris*, but nothing near ſo *vivid* as in the common Rainbow. The *Reds* were next the Sun, and the *Blews* in the outward Limb. Within this Circle the Sky appeared ſomewhat obſcure, eſpecially near the Arch; and I take it, that the Cauſe of that Obſcurity was likewiſe the Cauſe that the Sun ſhone ſo faint and wateriſh I expected two *Parhelia* at *X* and *Y* in the Interſections of this with the white Circle, having often ſeen them at that Diſtance and Poſition from the true Sun, but at this time none ſuch appeared.

PVP, an Arch of another Circle, of which only the upper Part appeared, it was in all Reſpects, both for Breadth and Colours like the Circle *VNXY*, which it touched in the vertical Point *V*, but its Center was below at *N*, or near it. In the Interſections of this Arch with the white Circle on both Sides, were two very bright *Parhelia*, ſo luminous, that I do not remember to have ſeen the like, which were alſo tinged with Colours, eſpecially on the Side next the Sun, where they were very red. I meaſured their Diſtance from the true Sun, and found it 31½ Degrees. About *V* where the two Arches were coincident, it was very bright likewiſe, and the *red* on the inſide very ſtrong, that ſome might have imagined another Sun there alſo, but the *Species* thereof was drawn out ſo in length, that it could not properly be called a *Parhelion:* This Arch *PVP* broke off on both ſides, about five or ſix Degrees below the *Parhelia P. P.*

At *N* or the lower Part of the Circle *VNXY*, there appeared likewiſe a ſmall Piece of an Arch, which touched it there, after the ſame manner as *PVP* touched in *V*; it ſeemed to have its Center in *V*, and about *N* there appeared another longiſh red *Species*, ſuch as at *V*, but not altogether ſo bright.

The Height of the Sun, during the Obſervation, was from 40 to 45 Degrees, when Clouds interpoſing, no more was to be ſeen; the Weather was cooler than ordinary, with a gentle *NW* Wind. And it was plain, that the Vapour which cauſed this Appearance, was higher than the Clouds, for they were ſeen to drive under the Circles.

Spots obſerved in the Sun, *in* June 1703. *by Mr.* S. Gray, n.288.p.1502.

X. *June* 15th, 1703. between 4 and 5 of the Clock in the Afternoon, I ſaw a Spot in the Sun, by placing a white Paper ſo far behind the Teleſcope of ſix Foot, as to give the Image of the Sun 9 Inches Diameter; the Spot was in the lower Right-hand Quadrant of the Sun's Diſk; its Form was almoſt round, inclining to an Ellipſis; it was diſtant from the Limb of the Sun about 6 or 7 Minutes, and its Diameter I judged to be about 10 or 12 Seconds: A little before the Sun ſet I ſaw the Spot with a 16 Foot Teleſcope, and could perceive that it was environed with a Miſtineſs. On the 16th I ſaw the Spot again about 2 in the Afternoon, and found it advanced near to the Weſtern Limb of the Sun; the 17th was cloudy, and ſo was the Night, which hindered me from obſerving the Eclipſe of the Moon; the 18th in the Afternoon it cleared up, and a little before 5, I ſaw the Spot with the 16 Foot Glaſs through thin Clouds, and found it was now very near the Limb of the Sun, little more than half a Minute; it was much contracted in its Breadth, ſo as to be 4 or 5 times longer than broad: On the 19th in the Morning, I looked for it again, but could not ſee it; ſo I concluded, it was then either gone off the Diſk of the Sun, or if it adhered to the Limb, the great Tremulation of the Atmoſphere hindered me from ſeeing it.

Aſtro-

Aſtronomers have by theſe Spots found, that the Sun revolves on its Axis, ſo as that in 27 Days the ſame Point in the Sun's Diſk, returns to the ſame Place ſeen from the Earth; hence its Semi-revolution in 13 ½ Days, and conſequently the Spot going off the Sun's Diſk the 19th of *June*, may be expected to return the 2d of *July* next to the Eaſtern Limb of the Sun's viſible Hemiſphere, if it be not diſſolved before that time. I have in the *Figure* endeavoured to expreſs the Appearance, but had not the Conveniency of meaſuring the Angle of the Spot's way, with the Vertical, which is only gueſſed at. Fig. 104.

June the 26th, 1703. In the Evening I looked to ſee, whether there were generated any new Spots in the Sun, but found none; but on the 27th about half an Hour after 8 in the Morning, by receiving the Sun's Image on white Paper from the 6 Foot Glaſs, I ſaw a Spot near the Vertical of the Sun towards the lower Limb, betwixt 9 and 10 I elevated the 16 Foot Tube, the Clouds now being of a convenient Thickneſs to let me ſee the Sun without prejudice to my Eyes, and found that this Spot was of a triangular Form, and that it was accompanied with 2 other leſſer ones, as is expreſt in the *Figure*; the Sides of the great Spot were curvilinear, this with 2 leſſer ones, made an Equicrural Triangle, at 4 in the Afternoon the triangular Spot had a ſmall Fragment ſeparated from it, and itſelf was now become Elliptical, the Spot *b* was much augmented, but the Spot *c* diminiſhed, and become longiſh, as in *Figure* 99. at half an Hour after 5 the Fragment from the great Spot, was itſelf divided into 2, and the Spot *c* was ſo narrow as ſcarce to be ſeen, as at *Fig.* 100. at 6 a Clock, and 30 Minutes there was a ſmall Fragment ſeparated from the lower End of the great Spot, as at *Figure* 101. at 7 a Clock the Spot *b* was much encreaſed, but *c* was vaniſhed; the Obſervations made this Afternoon with the 16 Foot Glaſs, were when the Air was clear, and ſo to ſecure my Eye, the Eye-Glaſs was ſmoaked with a Wax-Candle. Fig. 98. Fig. 99. Fig. 100. Fig. 101.

The 28th about 7 in the Morning, I ſaw that the great Spot was much augmented, but the leſſer ones that yeſterday attended it, were vaniſhed, and that there were two new ones generated at about 1 ½ minutes Diſtance from the great one below, and towards the Left-hand of it the great one was a Paralellogram, with a black diagonal croſſing it *Fig.* 102. at 10 a Clock there was another diagonal croſſing the former *Fig.* 103. and the two leſſer Spots which before were longiſh, had now taken a round Form, the Spot *c* being much larger than the other at *b*. Fig. 102. Fig. 103.

I am not yet furniſhed with proper Inſtruments to find the Poſition of the Sun's Spots, with reſpect to Longitude and Latitude on the Sun's Diſk, ſo I contented myſelf with obſerving the Poſition and Variation of the Spots among themſelves, which afforded me a moſt ſtrange and wonderful Variety.

2. The

On the same, by Mr. W. Derham, *ibid.* p. 1504.

2.] The two Circles *Fig.* 105, 106. repreſent the Sun's Diſk, and N. the Northern Part thereof, S. the Southern, E. the Eaſtern, and W. the Weſtern Part.

Fig. 105, 106.

The Place of the Spots, and the Manner of their Appearance every Day, is repreſented with the Day of the Month on the Sun's Diſk.

But I deſire it may be obſerved, that although the Figures of the Spots are done pretty exactly, yet their Places on the Sun are not ſo, for being unprovided with convenient Inſtruments for the Purpoſe, I could not exactly ſet off their Delineations, nor their Diſtances from the Sun's Limb, but was forced to repreſent them only as well as I could, by taking the Species of the Sun upon Paper, through a Teleſcope, and ſo marking out their Places.

But ſince the laſt Appearance of the Spots, I have invented, and have provided myſelf with an exceeding nice Micrometer, and a Watch that beateth half Seconds, hoping to have been able to have ſeen another Revolution of them.

My Micrometer is not, as uſually, to be put into a Tube, but is to meaſure the Species of the Sun on Paper (of any *Radius*) or to meaſure any Part of it, which I am inclined to think is more exact than the common way. By this Means I can eaſily, and very exactly with the Help of a fine Thread, take the Declination of a Spot at any time of the Day; and by my half Second's Watch, and a fine croſs Hair (which latter way I learnt from my Friend Mr. *Flamſtead*) I can meaſure the Diſtance of the Spot from the Sun's Eaſtern or Weſtern Limb.

This croſs fine Hair, I adviſe, from my own Experience, ſhould be ſet, not at the exact focal Diſtance from the Eye-Glaſs (as uſually) but a little out of that Diſtance, nearer towards the Object-Glaſs, becauſe the Shadow of the Hair will be thereby much narrower, and more ſtrongly appear croſs the Species of the Sun received on the Paper, which I take this Occaſion to note, not only becauſe I believe it hath ſcarcely ever been before obſerved, but becauſe it may be of good uſe in taking the Sun's Altitude, meaſuring his Diameter, *&c.* this being a more eaſy, and perhaps a more exact way, than by looking through the Tube.

Being thus provided, if I could have ſeen another Revolution of the Sun's Spots, I ſhould have been able to have given a more accurate Account of their Poſition and Motion. They ſeemed ſtrong enough to have laſted another, or more Revolutions, but none have been viſible ſince the ſixth of this Month, on which Day I think I had a glimpſe of a Spot on the Sun's Weſtern Limb, about 7 of the Clock in the Morning.

The

The Appearances of the Spots, being in the Figures above, ſet with every Day of the Month, I need ſay but little, only take notice of a few things, that the Figures do not ſo well expreſs.

The Spot in *Fig.* 105. was as repreſented, *viz.* 1ſt round and ſtrong, afterwards long, and with a *Nucleus*. The very ſame Spot (I doubt not) I ſaw again on the Sun's Eaſtern Side on *July* 5, but very faint, ſmall and long (as in *Fig.* 106.) ſo as to be but juſt diſcernable. On *July* 6 it quite diſappeared, both through my Tubes, and on Paper, which is better.

The Spots in *Fig.* 106. had theſe remarkable Appearances and Variations. On *June* 28 viewing the Sun towards Evening, I eſpied a large, ſtrong dark Spot, with two or more glaring *Nubeculæ* behind it, ſomewhat like the Repreſentation in the Figure. Theſe the next Day were become four ſtrong dark Spots, the foremoſt with a Tail to it, conjoining the little Spot next it, as in the Figure. On *June* 30. I ſaw Spots, but it being a cloudy Morning, and I abſent from my Tubes in the Afternoon, the Repreſentation of them in the Figure is not exactly as they were. *July* 4. between two long Spots appeared ſomething like a round *Nubecula*, as in the Figure. The reſt as in the Figures.

Thus I have given the beſt Account I could of the late Solar Spots. The ſingle Spot in *June* may be ſeen to have paſſed above half over the Diſk, before a Friend of mine gave me Notice of it. And that and ſome others were, I hear, ſeen in *May*; but it was not my Fortune to ſee them ſooner; which if I had, I ſhould have been able to have made my Account better.

Spots obſerved in the Sun, *in* 1704. *by Capt.* Stannyan, n. 294. p. 1756.

On *Saturday*, *May* the 15th, 1703, As I was obſerving the Setting of the Sun, in order to examine my Clocks, there appeared two Suns, the Mock-Sun ſeemed above the Real one, which was then only five Degrees above the Horizon. Whereupon I took a good Seven-Foot Teleſcope, with a ſmall Aperture, and ſoon diſcovered a Solar Spot near the Sun's Center, which I deſigned to obſerve more exactly the Day following, but it proved cloudy.

May.

Sunday no Sun-ſhine.

Monday, *May* the 17th, At Six a Clock in the Morning I took the ſame Teleſcope, armed with a clouded Eye-Glaſs, and immediately perceived that the Spot was advanced conſiderably towards the Sun's Weſtern Limb; it ſeemed of a ſtrong Conſiſtence, very compact, reſembling a Face, and was diſtant by Noon from the Anterior Limb of the Sun's Diſk 61 Seconds of Time. See *Fig.* 107. Fig. 107.

Tueſday, *May* the 18th, At Noon I found the Spot diſtant from the preceding Limb 46 Seconds of Time. *Fig.* 107. Fig. 107.

Wedneſday, *May* the 19th, At Noon I obſerved the Solar Spot to be moved within 33 Seconds of time of his Weſtern Limb. *Fig.* 107. Fig. 107.

Thurſday,

Thurſday, *May* the 20th, At Noon the Spot was arrived within 21 Seconds of time of the preceding Limb, and moving nearly in a ſtrait Line. Interſecting the Parallel of Declination paſſing through the Sun's Center. *Fig.* 107.

Fig. 107.

Friday, *May* the 21ſt, We had no Sun-ſhine.

Saturday, *May* the 22d, At ſeven a Clock in the Morning I obſerved the Solar Spot was advanced very near the Limb of the Sun's Diſk. *Fig.* 107.

Fig. 107.

Sunday, *May* the 23d, At ſix in the Morning I ſaw the Spot, which by that time was got to the very Edge of the Sun's Diſk, reſembling a Barley Corn, lean and ſlender, and of a Duſkiſh Colour, wanting only its own ſhorteſt Diameter of the Sun's Limb. At Eight a Clock I obſerved it again: Alſo at ten, and at twelve. At two I perceived it was ſlid into the very Circumference, and hardly viſible, had I not had an Eye upon it all the Day long. At four I examined the Sun's Body with my eighteen Foot-Glaſs, which is a good one, but could not perceive the leaſt Glimpſe of it; ſo that about three in the Afternoon it totally diſappeared. *Fig.* 107.

Fig. 107.

June. On *Thurſday*, *June* the 3d, About ſix in the Evening I obſerved with my eighteen Foot-Glaſs four Spots in the Sun's Diſk, environed with a Miſtineſs, thicker on the Right-hand than on the Left, ſituated in the upper Left-hand Quadrant, about the 12th Part of the Sun's Diameter diſtant from his neareſt Limb. From the Cloud about them proceeded both ways five long curve Rays, of a yellower Colour than the Sun's Body. Theſe Spots I could never ſee more, though I watched them for ſeveral Days together. *Fig.* 108.

Fig. 108.

On *Monday*, *June* the 7th, 1703. At three a Clock in the Afternoon I diſcovered the ſame Spot (to my thinking) that I ſaw go off the Sun's Diſk on *May* the 23d, re-entring the Sun's Face juſt at the Time and Place that I expected it.

At four of the Clock, the Sun being extremely clear, I mounted my eighteen Foot Teleſcope, through which the Spot appeared diſtinct, but ſlender like a Spider, with an Elliptical ſpeckly Miſt about it, and 5 or 6 Light coloured Streaks. It ſeemed to me to be as it were divided near the Top, as in *Figure* 109.

Fig. 109.

Tueſday, *June* the 8th, At ſix in this Morning the Spot was very viſible, and I ſaw it trace again its former Path, coming in exactly where I expected; it kept its Shape, but thoſe Limon coloured Streaks diſappeared, though itſelf and the Miſt about it grew bolder and broader viſibly, as it re-entred the Sun's Diſk.

Wedneſday, *June* the 9th, At five of the Clock this Evening I obſerved the Spot with the eighteen Foot-Glaſs, but could not perceive it had altered its Shape, but advanced gradually over the Sun's Diſk, as it had formerly done.

Thurſday, *June* the 10th, At Noon the Sun ſhining very bright, I had an Opportunity of being aſſured it was the ſame Spot, I plainly

ſaw it move over its former Path, and was then diſtant from its neareſt Limb 29 Seconds of time. At five in the Evening I obſerved its Shape (with my 18 foot Tube) to be altered, appearing bigger and blacker than ever, as in *Fig.* 110. Fig. 110.

Friday, *June* the 11th, was an ill Day for Obſervations, but I had a Sight on't with the 18 foot Glaſs; it continued black and bold, as before.

Saturday, *June* the 12th, At 7 a Clock in the Morning, the Sun's Body being very clear, I ſaw the Spot through the 18 foot Glaſs, retaining its former Shape.

Sunday, *June* the 13th, By this Day Noon the Spot was arrived at the ſame Point of the Sun's Diſk, that I found it in on *Monday* at Noon, *May* the 17th; which makes me inclinable to believe it was the very ſame Spot.

Monday, *June* the 14th, according to Rules received Yeſterday from Mr. *Flamſtead*, I meaſured the Diſtance of the Spot from the next Limb of the Sun's Diſk, which I found to be 45 Seconds of time from the anterior Edge of the Sun's Body: And upon *Tueſday*, *May* the eighteenth, it was obſerved to be in the very ſame Place of its Path, within a ſingle Second of time. At 4 I obſerved it with my 18 foot Glaſs, and perceived that it had altered its Shape, appearing as at *Fig.* 111. I received it on the Scheme, and it was diſtant from the preceding Limb 612 ſuch Parts, as the Sun's Semidiameter is 900. Fig. 111.

Tueſday, *June* the 15th, At Noon the Solar Spot was diſtant 32 Seconds of time, from the leading Limb of the Sun's Diſk, and covered the very Place, where the ſame Spot had been obſerved on *Wedneſday* the nineteenth of *May*.

Wedneſday, *June* the 16th, No Sun-ſhine.

Thurſday, *June* the 17th, No Sun-ſhine.

Friday, *June* the 18th, At Noon I obſerved the Solar Spot waxing very ſlender, but notwithſtanding that, it was black and bold to appearance, the Miſtineſs about it on the Right-hand perceivable, and that on the Left grown ſlender, in proportion with the Spot itſelf, and found it diſtant 5 Seconds of time.

Saturday, *June* the 19th, At 5 this Morning, it being clear Weather, I ſaw the Spot diſtinctly with my 7 foot Tube: At 9 a Clock I mounted my 18 foot Glaſs, obſerving once in half an Hour all the Morning: At 12 I perceived, that all the Cloud or miſty Matter, that uſed to ſurround the Spot, was inviſible, and the Spot itſelf reduced to little or no breadth, in Compariſon to what it had been towards the Sun's Center, and ſo cloſe to the Limb of the Diſk, that I could only perceive a ſmall Streak of the Sun's Light between it, and the Limb of the Sun's Body; at 2 a Clock I could juſt perceive it, but grown extremely ſlender.

The firſt Revolution, I ſaw the Spot half in the Circumference of the Sun's Limb at 2 a Clock on *Sunday*, *May* the 23d: And the ſecond Revolution, I juſt perceived it with the 18 foot Glaſs, at half an Hour after two a Clock on *Saturday* the 19th. Day of *June*.

On *Sunday June* the 27th, about ſix a Clock in the Evening, I obſerved ſeveral Spots in the Sun's Diſk, but had not the Conveniency to uſe my longeſt Teleſcope, becauſe of ſome Trees that were in my way to Weſtward, ſo that I made no Obſervation till *Tueſday* following.

Tueſday, *June* the 29th, About 7 in the Morning I counted 16 Remarkable Spots in the Sun's Body, and near his Center they appeared as
Fig. 112. in *Fig.* 112. through the 18 foot Glaſs; then I took my ſeven foot Teleſcope and Frame, and obſerved that the foremoſt Center of ſix, that looked on the Paper as one Spot, was diſtant from the Sun's anterior Limb 81 Seconds of time, and the laſt Cluſter 87.

This Day the foremoſt Spot was diſtant from the following Limb, according to the Path of the Spot, juſt 55 Seconds of time. The Sun's Diameter was always 136 Seconds in the Tranſit, and the Spot was 126: So that the Spots Path was 10 Seconds ſhorter than the Sun's Diameter.

Wedneſday, *June* the 30th, At eight a Clock this Morning, obſerving the Solar Spots with my 18 foot Teleſcope, I perceived very plain, that they had wonderfully increaſed in Number, and ſtrangely changed their Places. The Cluſter of ſeven Spots ſeemed to me to move gradually, as the ſingle Solar Spot did in *May*, but the Cluſter 4 went too
Fig. 113. faſt forward, the 12 Spots without a Miſt about them ſtraggled all manner of ways, and the 9 Spots and the five black little ones went backward and unbent itſelf at the ſame time as it were into a ſtraight Line. I am apt to believe it went backward, as that the other went too faſt, or faſter than ordinary forward; for in 24 Hours, the foremoſt Cluſter advanced 21 Seconds of time, which is more by ſix Seconds than ever the ſingle Spot moved in that time, even when neareſt the Sun's Center; and the Diſtance in time between the firſt and the laſt Cluſter this Day was greater by 3 Seconds than the Day before.

The foremoſt Cluſter of 4 Spots was diſtant from the advancing Limb of the Sun 60 Seconds of time.

At half an Hour paſt 4 the advancing Cluſter paſſed the Interſection in 55 Seconds of time, after the Sun's foremoſt Limb had paſſed conformable to the Spots Path; and the laſt Spot paſſed in 63 Seconds of time, the laſt Limb paſſing the Interſection, according to the Path
Fig. 113. of the Spot, in 126 Seconds of Time, the Sun's largeſt Diameter paſſing in 136 Seconds; the Spots by this time appeared ſtrangely black, and of very odd Shapes, as in the upper Part of the Circle.

July. *Thurſday*, *July* the 1ſt, At eight a Clock in the Morning, I obſerved the Solar Spots with my eighteen foot Teleſcope, the Weather being good, and ſaw that they had ranged themſelves in reſpect of one another,

ther, as is repreſented in the upper Part of the Scheme: The leading and largeſt Spot being diſtant from the anterior Limb 44 Seconds of time, the laſt Cluſter lying a little awry, paſſed in 53 Seconds: After the anterior Limb had ſo done, the following Limb alſo paſſed the Interſection, according to the Path of the Spot, in 125 Seconds of time. Fig. 114.

Friday and *Saturday*, No Sun-ſhine.

Sunday, *July* the 4th, This Morning at eight a Clock the leading Spot was diſtant from the advancing Limb 10 Seconds of time, the Spots and Cluſters retaining nearly the ſame Shape, but beginning to contract themſelves, the foremoſt methought looked ſtrong enough to make another Revolution, and paſſed in 127 Seconds.

Monday, *July* the 5th, At ſeven a Clock I found the Spots had quite altered their Shape, appearing dull and ſlender, as in the lower Part of the Scheme, and diſtant about four Seconds, being all included in a Cloud.

Tueſday, *July* the 6th, At ten a Clock the Sun's Diſk, viewed with my 18 foot Teleſcope, was found clear of all Spots.

On the 17th Day of *July*, about four a Clock in the Afternoon I obſerved ſome Spots in the Sun's Body, reſembling thoſe I ſaw on *Thurſday* the third of *June*, only with this Difference, that theſe appeared to me, as if they had been heated red hot; they ſeemed to be in the ſame Part of the Sun's Diſk. I obſerved them above an Hour together that Day, but could never afterwards ſet Eye on them, nor diſcover whether they were coming in, or going off his viſible Diſk. I continued to obſerve the Sun, as often as was poſſible, with my eighteen foot Glaſs, till the End of the Month, but without farther Succeſs.

4.] I have endeavoured to render this Account of the Spots of the Sun more complete than my former; few of thoſe Appearances having eſcaped my Sight; and being alſo better provided with competently good Inſtruments to take their Places on the Sun, *viz.* a *Micrometer* (after Mr. *Gaſcoigne*'s manner) to take their Diſtance from the Sun's Northern or Southern Limb, which is Parallel with the Pole of the Earth; and a *Half-Second's Movement*, to meaſure their Diſtance from the Sun's Eaſtern or Weſtern Limb. Spots *in the* Sun *from* 1703, *to* 1708. *by Mr.* W. Derham, n. 330. p. 270.

A Table of all the Spots *and* Faculæ *on the* Sun, *visible at* Upminſter, *ſince* July 1703.

1703.		*Jun.* 23. *none*		8		30		*Feb.*	14	*Nov.*	1
		Some	24	*	10				15		4
Octob.	9	*Vaniſhed*	25	*	22	*April*	2		16		8
	10			*	23	*Vaniſhed*	3		18		10
	11	*July*	18						24	N. B. *This*	15
			20	*June*	22	*June*	7			Nov. 15.	16
Nov.	19		21		23		8	*March*	6	*another Spot*	17
	22	*	23		24				9	*aroſe on the*	18
					26	*July*	24		11	*Eaſtern ſide*	19
		Sept. *	10		27		25		12	*of the Disk*	20
		nothing	14		28					*whilſt this*	22
1704.			18		30	*Sept.*	4		14	*on the We-*	
		*	21	*July* *	1		5		18	*ſtern.*	
Jan.	16			*	3		6		21		
	17	*Nov.*	17				7				
	18		18		24		8	*June* *	29		
	19		21				10	*Extinct*	30		
	21			*Sept.*	30	*Faint*	11				
	22	*Dec.* *	2	*Octob.*	2	*Extinct*	12	*July*	1		
	23				3			*Languid*	2		
					5	*Oct.* *	29	*Scarce visible*	4		
		1705.			6			*More visible*	5		
Jan.	30				7	*Nov.*	5	*Extinct*	6		
						Faint	6	*Appears*	8		
Feb.	23	*Jan.*	1		25	*	8	*	10		
	25		2		26						
			3		30		28	*Aug.* *	31		
Mar.	7		5		31		29				
	8			*Nov.*	2		30	*Sept.* *	12		
	9	*	25		4	*Dec.*	1		16		
	10						2	*Spot &* *	17		
	11	*Feb.* *	19	*	21		3		19		
	13						4		21		
		March	14	1706.			5		27		
			16					*No Spot nor* *	28		
April	11					*	22				
	12	*April*	1	*Feb.*	7	*	31	*Octob.*	31		
	13										
		May	5	*Mar.*	7						
May	1		6								
*	11		7		27	1707.					

In

In this Table the *Faculæ* are noted with an Aſteriſk; and the Duration of every Appearance of the ſame Spots or *Faculæ*, or the time they diſappeared, with a Line.

Out of many things, that I took Notice of in viewing the Spots and *Faculæ*, I ſhall ſelect only ſome few Obſervations, which are the moſt Remarkable.

And firſt, as to the *Figure* of the Spots. They are well known to change frequently; and therefore I think it of little uſe to give their Figures every time I obſerved them. But it is ſomewhat remarkable, that the Spots generally appear longiſh near the extreme Parts of the Diſk. If they are never ſo round near the middle of the Diſk, they become longer and longer towards the Extremes, till (at going off) they ſeem to be nearly a ſtrait Line, nearly parallel to the Sun's Limb. Which is a manifeſt Argument, that the Sun is a Globe, and that theſe Spots are on, or very near its Surface.

Another thing remarkable is, The *Mutability* of the *Shape* of the Spots. I have more than once manifeſtly perceived them to change in the very time I have been looking upon them. Thus *Nov.* 19. 1703, I ſaw three or more Spots not far off the middle of the Diſk; and whilſt I was looking upon them, they ſeemed to vary, both as to their Shape and Strength; ſometimes ſeeming longer, ſometimes ſhorter; ſometimes ſpiſs, ſometimes languid. And this they ſeemed to do, not only through my 16 Feet Tube, (which I thought at firſt was from the different Diſpoſition of my Eye) but alſo when I received the Sun's Image through a ſix Feet Teleſcope, on a white Paper, in a darkned Room. Theſe mutable Spots the Weather hindred me from ſeeing again till *November* the 22d following; and then they were become only like a thin Smoak, or *Nebula*.

So again *April* 11. 1704. there were diverſe Spots with *Umbræ* about them. Theſe *Umbræ*, or *Nebulæ*, I could plainly perceive, whilſt I was looking on them, to be ſometimes very faint and thin, and ſometimes much darker and thicker. Theſe *Maculæ* and *Umbræ* I obſerved ſuddenly brake out in the Sun: For, on *April* 9. the Diſk was free. But this *April* 11. laſt mentioned, I perceived them advanced near a quarter Part on the Diſk: And conſequently they brake out in the Sun within 48 Hours before. On *April* 13. the *Spots* were become *Umbræ*, in the Morning; and at four of the Clock in the Afternoon, there were no Remains of either *Maculæ* or *Umbræ*.

From this *ſhort continuance* of theſe Spots on the Sun, it is more than probable, they were in a perpetual Flux and Change; and that thoſe Mutations, which I perceived in them, whilſt I was looking on them, were real, not imaginary.

Alſo it may be farther remarked, (which I have frequently obſerved, and which as I remember *Scheiner* obſerved long ago) That thoſe *Spots* and *Umbræ* which *ſuddenly* ariſe, do as *ſuddenly* decay, and are ſoon

extinct. And ſuch Spots, I have farther obſerved, do ſeldom turn to *Faculæ*, as they commonly do when longer on the Sun.

Again, *May* 5. 1705. I could perceive two Spurs or Branches (running from a Spot) to change, and be ſometimes darker, ſometimes thinner.

So *March* 30. 1706. I obſerved ſuch another Variation. This Day, or but a little before, *Spots* with *Faculæ* aroſe in the Sun, which remained not above three Days on him. One of theſe Spots I could manifeſtly perceive to be ſometimes quite extinct, and then again immediately to appear: And the *Faculæ* alſo, in half an Hour's time, had plainly altered their Shapes.

October 29. the ſame Year, I could plainly perceive the *Maculæ* and *Faculæ* both to change: And whilſt I was carefully viewing them, I ſaw a Spot ariſe in one of the brighteſt *Faculæ*, and again nearly diſappear; and then again appear ſtrong and ſpiſs. I ſhould have been glad to have ſeen how they appeared next Day; but the Weather was ſtormy, cloudy, and wet for ſeveral Days after.

Another thing I have obſerved (and not having the Book by me, I forget whether *Scheiner* obſerved the ſame or not) is, That the *Maculæ* do generally, if not always, become *Nebulæ* or *Umbræ*, before they quite vaniſh; and after that, very frequently turn to *Faculæ*, or bright golden Spots, more illuſtrious and fulgid than the other Parts of that glorious Globe. If the Spots are of a ſhort Duration, *Faculæ* ſeldom enſue: Or if they do, they are commonly the Remains of ſome Spots that had been on the Sun, and vaniſhed perhaps on the Side oppoſite to us. But Spots that *long continue*, if they vaniſh, before that Part of the Sun revolveth out of our Sight, do very often become *Faculæ*. Of which the Table affordeth ſeveral Inſtances, particularly *July* 3. 1705.

From theſe preceding Particulars, and their congruity to what we perceive in our own Globe, I cannot forbear to gather, *That the Spots on the Sun are cauſed by the Eruption of ſome new Vulcano therein*; which at firſt, pouring out a prodigious Quantity of Smoak, and other opacous Matter, cauſeth the Spots: And as that fuliginous Matter decayeth and ſpendeth itſelf, and the Vulcano at laſt becomes more torrid and flaming, ſo the *Spots* decay and grow to *Umbræ*, and at laſt to *Faculæ*; which *Faculæ* I take to be no other than more flaming brighter Parts than any other Parts of the Sun. Theſe *Faculæ* I have obſerved *never* continue *long* on the Sun: And the Reaſon I conceive is, becauſe the *Vulcano*, after its Smoak is over, doth not long emit its Flames; by reaſon the fiery *Pabulum* is then near ſpent, when once it begins to flame: After which the torrid *Vulcano* ſoon returneth to the natural Temperature of the Sun, ſo nearly at leaſt, as to eſcape our Sight, at ſo vaſt a Diſtance as the Sun is from us.

Another thing, that may be accounted for, and indeed doth in ſome Meaſure confirm alſo what I have ſaid, is the *Nucleï*, or darker Part of

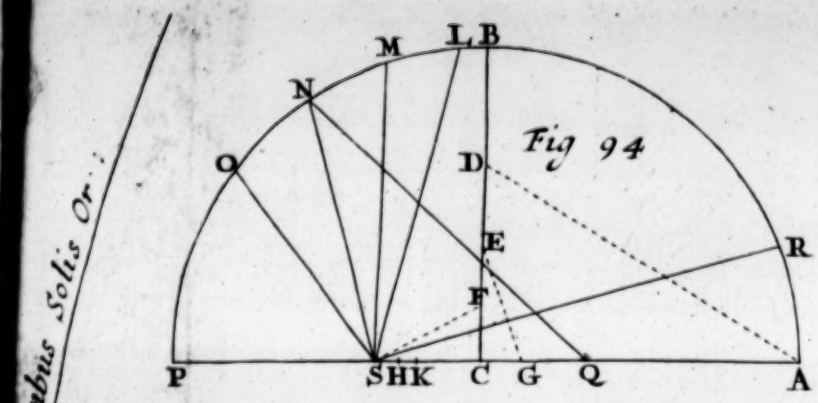


Fig 94

Limbus Solis Or.

Figura Veneris Solis Discum intrantis.

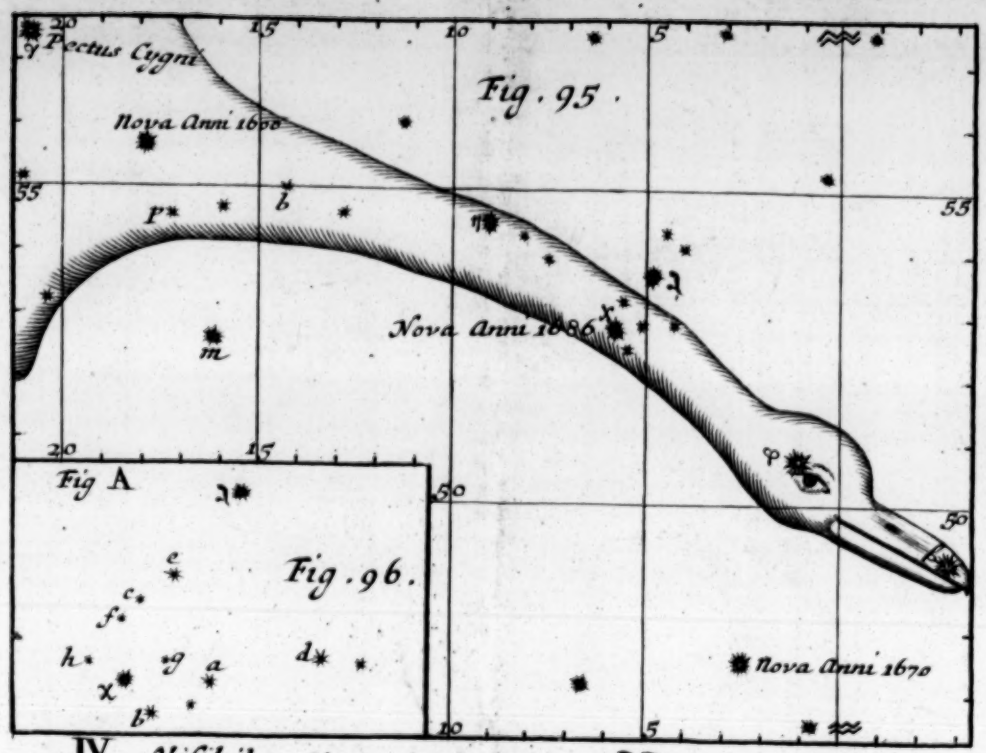


Fig. 95.

Fig. 96.

III Via OF M

IV Visibilis Veneris

V infra

H

K Differentia semidiam. Solis

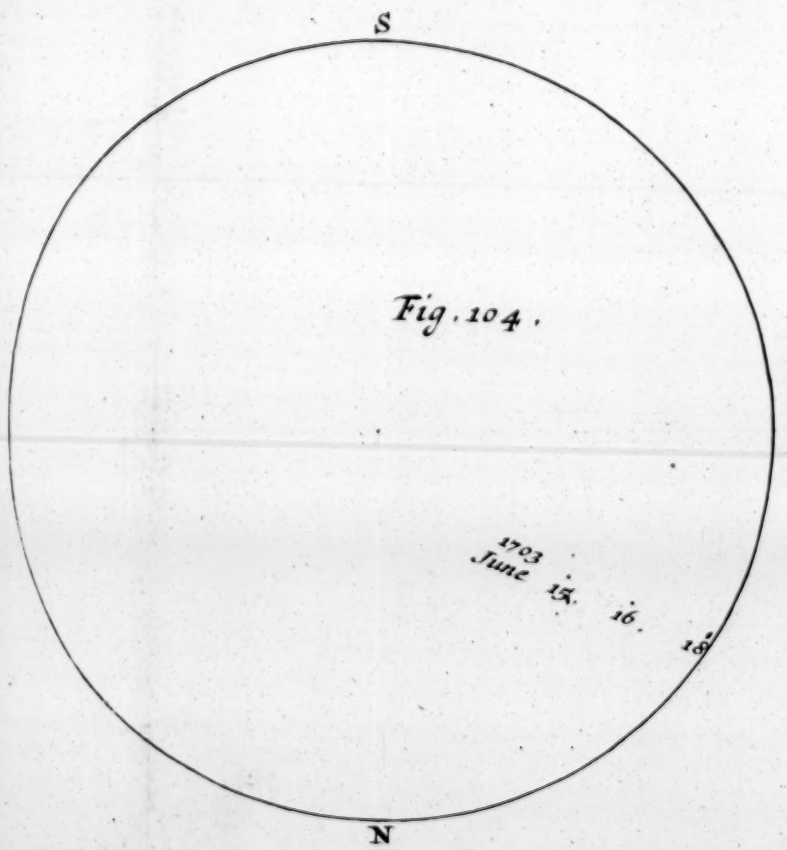


Fig. 104.

1703 June 15. 16. 18.

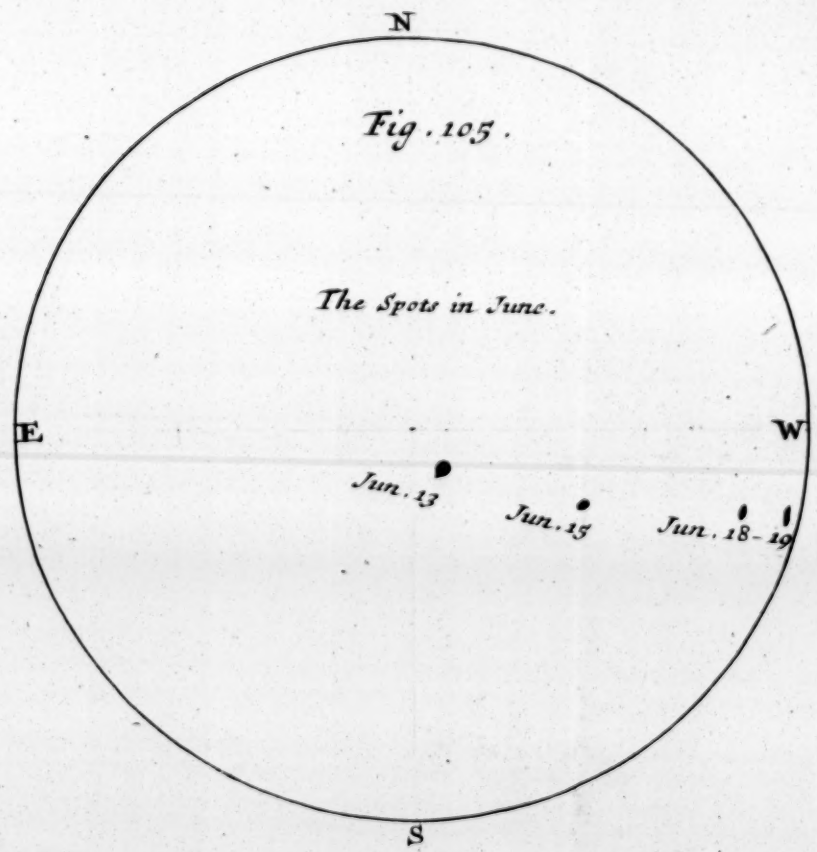


Fig. 105.

The Spots in June.

Jun. 13 Jun. 15 Jun. 18-19

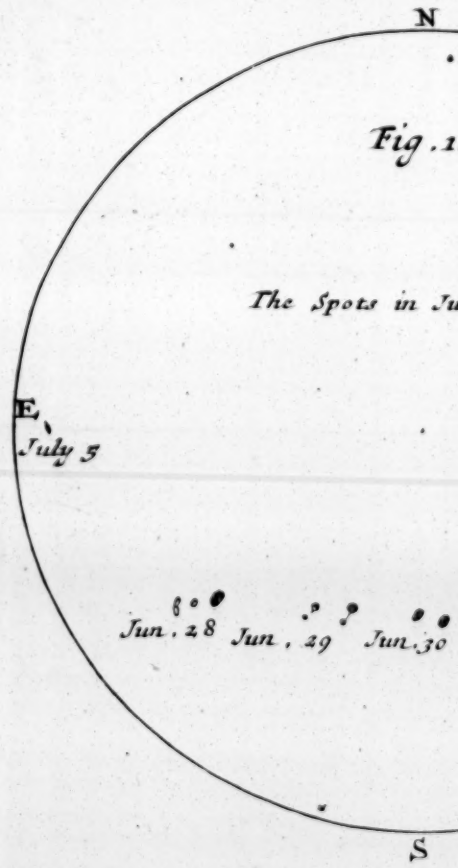
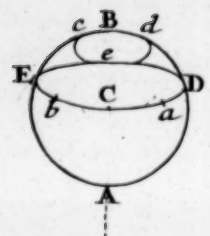


Fig. 1

The Spots in Ju

July 5

Jun. 28 Jun. 29 Jun. 30



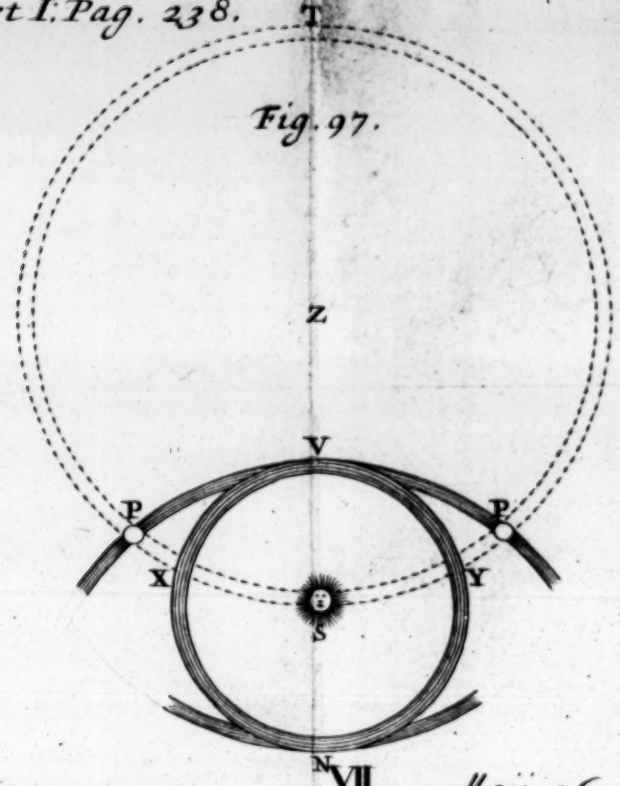


Fig. 97.

Fig. 98.

Fig. 99.

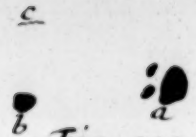


Fig 100

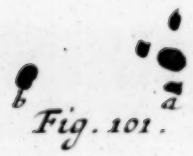


Fig. 101.

Fig. 102.

Fig. 103.

Limbus Solis Occ.

Figura Veneris exeuntis.

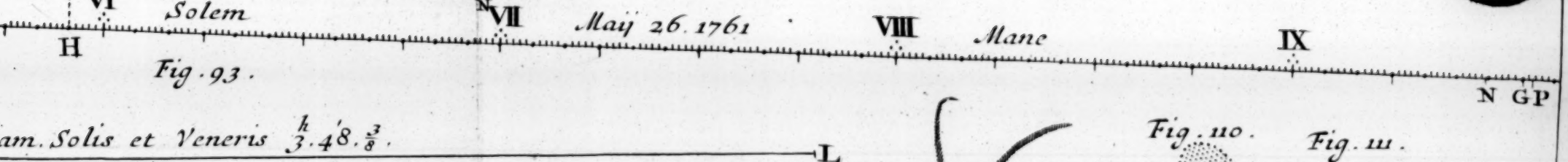


Fig. 93.

Diam. Solis et Veneris $\frac{h}{3}.48.\frac{3}{8}$.

Fig. 109.

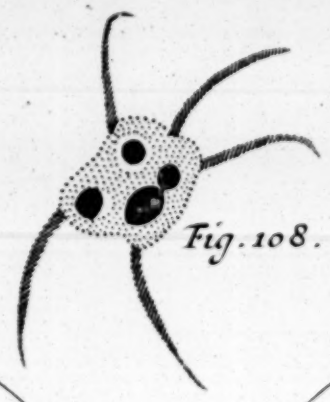


Fig. 108.

Fig. 110.

Fig. 111.

Fig. 106.

Spots in June and July.

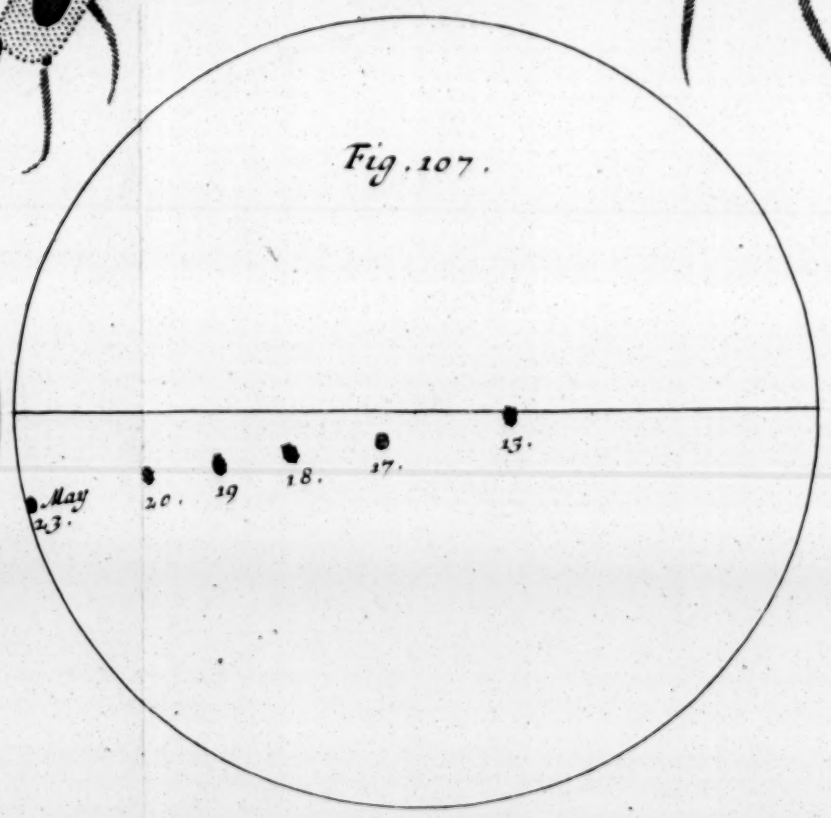


Fig. 107.

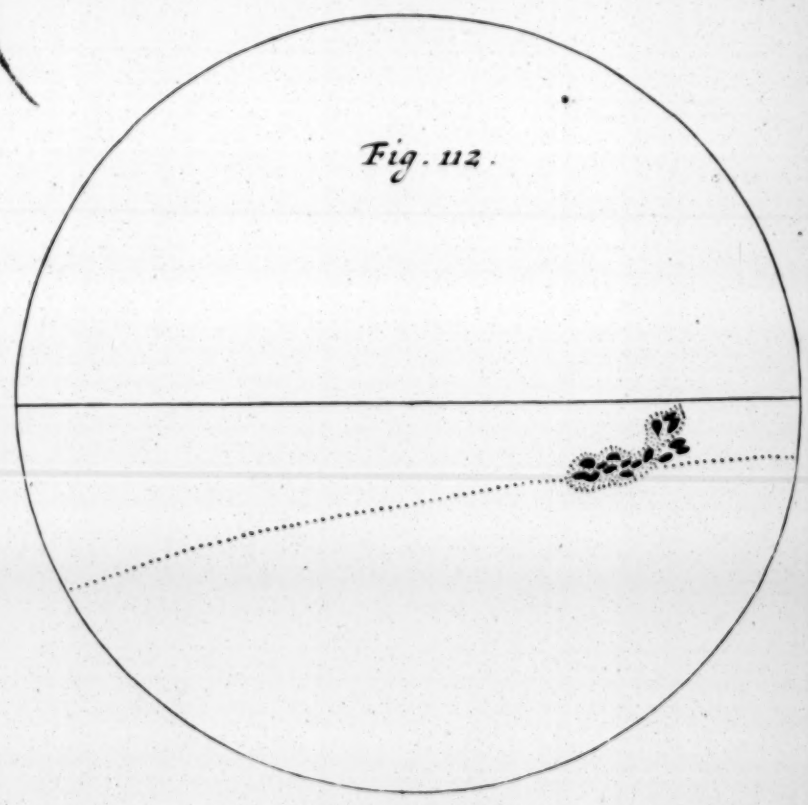


Fig. 112.

of the Spots; generally in moſt Spots, and towards the middle of them. Now it is very uſual in culinary Fires in this our Globe, when they emit Smoak, that the middle is the darkeſt Part. If, for Inſtance, we were from aloft in the Air, to ſee a thick Smoak come tumbling out of a *Chimney*, or the Mouth of a *Vulcano* juſt kindled, we ſhould find the middle Part, juſt over the Mouth of the *Chimney*, or *Vulcano*, to be more ſpiſs and dark, and towards the Extremes clearer and thinner. And ſo I take it to be in the Eruptions of the Sun; that the *Nucleus* is juſt over the Mouth of the ignivomous Cavern, and that the miſty Parts of the Spot are the thinner Parts of the Smoak, ſwimming about in that Fluid, or *Atmoſphere*, which I ſuppoſe doth ſurround the Sun, as well as our Globe, and the Moon manifeſtly; yea, and in all probability, every Planet of this our Solar Syſtem.

From what hath been ſaid, we may give a Reaſon, why there are ſometimes Spots *frequently* on the Sun, and ſometimes *none* in many Years. One thing I believe there is in this, That there may be Spots, but not always ſeen. But there are doubtleſs great Intervals ſometimes, when the Sun is free; as between the Years 1660 and 1671, 1676 and 1684. In which time Spots could hardly eſcape the Sight of ſo many curious Obſervers of the Sun, as were then perpetually viewing him with their Teleſcopes in *England*, *France*, *Germany*, *Italy*, and all the World over; whatever might be before, from *Scheiner*'s time. The Reaſon of this long diſappearance of the Spots, I take to be from the want of extraordinary Eruptions in that fiery Globe. The ſulphureous, or other Matter, or *Pabulum* of thoſe Eruptions, is ſpent or diſſipated, and that Globe continues in its natural ordinary burning State, till there happens to be a freſh Collection of ſmoaking, diſploſive, and extraordinary Matter, that cauſeth a new Eruption. Which Eruptions generally happen between what we may call the Sun's *Tropicks*, or in his Torrid Zone: For I never obſerved any Spots to be near the Sun's *Poles*. And if I miſremember not, the Spots in *Scheiner*'s Cuts are all about the middle *Zone* of the Diſk. The greateſt Evagation I ever obſerved of them was *March* 8. 17$c\frac{1}{4}$. On which Day, beſides the dark Spots in the uſual Zone, I perceived ſome faint Spots, ſcarce viſible, much nearer the Southern Pole, than I ever had ſeen them. But this was, no doubt, in ſome meaſure owing to the Poſition of the Earth in reſpect of the Sun, as well as to the ſoutherly Place of the Spots on him: For, about the Equinoxes, the Spots ſeem to march pretty far towards the Poles of the Sun, as may be ſeen by the *Schemes*. Fig. 115, 116.

Having thus obſerved, what *Part* of the Sun the Spots commonly poſſeſs, I ſhall next take Notice of their *Stages* and *Path* over the Sun. That the Sun moveth round his own *Axis*, is manifeſt, beyound doubt, from the Motion of the Spots. And that the Spots ſeem to traverſe the Sun, ſometimes in ſtrait Lines, ſometimes in

curve Lines, curved this way, and that way, is as manifeſt alſo, and well known, and is ſet forth in the Figures: Which Figures ſhew the Stages of the Spots, every Day that I obſerved them, and the Lines they deſcribe in ſeveral Months of the Year. The daily Stages in both Figures are exact; or if they ſeem otherwiſe, it is by reaſon the Obſervations were made at different times of the Day; as one in the Morning, the other ſome following Day in the Evening, or Afternoon. But the Declinations of the Spots, or their Diſtances from the Sun's Northern or Southern Limb, are leſs exact in the 116th Figure than the 115th, in which latter they are very near the Truth.

And the Cauſes of the Defects in the 116th Figure I ſhall mention, to prevent the ſame Errors in others I myſelf ran into.

1. The Diminution of the Sun's vertical Diameter by the Refractions was the principal Cauſe of my Errors. This although I was ſufficiently aware of, yet I did not think had been ſo conſiderable, for want of experimenting, or well conſidering the Matter: For I have ſometimes found the perpendicular, or vertical Diameter of the Sun diminiſhed, from 32′, 21″ on the Meridian, to 26′, 3″ at the Horizon, in one and the ſame Day.

2. For the ſame Reaſon I was not aware of the time being ſo long, before the Sun goes round, as I found it.

3. Another Error was meaſuring the Sun's Image on the Scene of white Paper, with the Shade of the Micrometer; and not by looking through the Tube, and ſo claſping the Limb of the Diſk with the parallel Edges of the Micrometer. The former, although practiſed by ſome eminent Aſtronomers, is a far more eaſy and indulgent, than accurate way.

—*Spots--from 1707, to 1711, by the ſame, ibid.* p. 278.

5.] I have ſince ſeen other Spots on the Sun, whoſe times are expreſſed in the *following Table.*

From my Obſervation of theſe Spots, I am farther confirmed in the Opinion I expreſſed in the foregoing Paper. Particularly in viewing the Spots of *Auguſt* 1. 1708. (repreſented *Fig.* 117.) where ſome were large and dark, others leſs and thinner, and all encompaſſed with *Nebulæ:* In viewing theſe, I obſerved great *Alterations* at the very time I was looking on them. Sometimes the *Nuclei* were very dark and black, ſometimes leſs ſo; and the ſame thing I obſerved alſo in the *Nebulæ* encompaſſing them. One of the leſſer Spots *b* in *Fig.* 117. which the Day before was ſufficiently viſible and ſtrong, was this Day, now thick and ſtrong, and anon languid and leſs viſible. And from the two Spots *a* and *d* I could plainly ſee a Smoak iſſuing out to *c* and *f*, ſometimes viſible for 5 or 6 Minutes, and then diſappearing for a quarter of an Hour, or more; and then again ſmoaking out, and again diſappearing, as before. All which Particulars, I ſaw over and over again repeated, for a good while together, till I was weary of the Obſervation.

Fig. 117.

Fig. 117.

Theſe

1707.		1709.	
Decemb.	4	*Jan.*	15
	10		21
			22
	* 29		
	* 30	*Auguſt*	13
		*	17
1708.		*Octob.*	8
July	31		
Auguſt	1	*Novemb.*	1
	5		2
	6		4
			5
	22		6
	23		
	24	1710.	
	28		
Septemb.	1	*Jan.*	22
Novemb.	5	*April* *	6
Dec.	14	*Octob.*	14
	26	*	18

Theſe Spots I was hindred from viewing until *Auguſt* 5. following: And then I found the Spot *b* quite extinct, (as I expected) as alſo ſome of the other Spots; together with the *Nebulæ* grown leſs. But the great Spot *a* continued dark and ſtrong, only ſometimes fainter, and then again ſtronger; and ſometimes like a half, or horned Moon; ſometimes roundiſh, or rather of an oval Figure; of which latter Figure they commonly are, when they are near the Sun's Limb, which this Spot was not far off at this time. Fig. 117.

Theſe Particulars are Confirmations of what I ſaid, *That the ſolar Spots are no other than a Smoak riſing out of the Body of the Sun.* Of which Opinion I have been, almoſt ever ſince I firſt obſerved them, and find that I am not ſingular in this Opinion, as I ſhall ſhew from part of a Letter (which with ſome others is lately fallen into my Hands) from Mr. *Crabtrie* to Mr. *Gaſcoigne*, the Inventor of the Micrometer.

Mr. Crabtrie's *Opinion of theſe* Spots, *in a* Letter *to Mr.* Gaſcoigne, *of* Auguſt, 7. 164●.

'I writ to Mr. *Townley* my Opinion in brief of the Sun's Spots, '(which you conceive to be Stars) and it ſeems he, or Mr. *Kay*, writ 'to the ſame Purpoſe to you, deſiring your Opinion: Which you free-'ly deliver: Yet give me leave to ſpeak my Mind likewiſe freely con-'cerning theſe Appearances. I do not value the Authority of *Galilæus*, 'or *Kepler*, further than either demonſtrative, or the moſt probable 'Reaſons confirm their Opinions. I acknowledge you ſay more for 'the ſtellifying of theſe ſolar Obſcurities, than I have heard before; 'yet I conceive not ſufficient, either demonſtratively or probably to 'countermand thoſe, which *Galilæus*, *Kepler*, and others have produced 'to the contrary; nor yet ſuch as can be cleared from ſuch Objections, 'as Reaſon, Demonſtration, and Obſervation may lay againſt them. 'My Occaſions will not admit a full Diſquiſition hereof at this time; 'yet ſomething I would ſay for the preſent, the better to furniſh you 'where to object, when I ſee you.

'I have often obſerved theſe Spots; yet from all my Obſervations 'cannot find one Argument to prove them other than *fading Bodies.* 'But that they are no Stars, but unconſtant (in regard of their Gene- 'ration) and irregular Excreſcences ariſing out of, or proceeding 'from the Sun's Body, many things ſeem to me to make it more than 'probable.

'For firſt, for their *Form*; they are ſeldom round, but of irregu- 'lar Shapes, and, as I have often ſeen, one Side, or End of the Spot 'more thin than the reſt, like to a certain miſty Darkneſs, and by De- 'grees thicker, groſſer, and darker, nearer to the main Body of the 'Spot; juſt as the Smoak of ſome pitchy Fire, which is in one Part 'very groſs, and in another more rare and thin, turning at laſt into 'mere Air: Or like a Cloud, Fog, or Miſt, more thick, dark, and 'groſs in the midſt; and more thin, fluid, penetrable, and tranſparent 'towards the Sides; which I ſuppoſe is not compatible with any of 'the Stars.

'Secondly, for their *Colour:* The Lightneſs thereof differenceth them 'from Stars, or Planets; they being never of ſuch abſolute Darkneſs, 'as I obſerved *Venus* the 24th of *November* laſt: Though I have ſeen 'Spots ſometimes little leſs than ſhe, yet always of a far paler and 'whiter Colour, looking (at leaſt in ſome Parts) like ſome thin diſſi- 'pated Subſtance.

'Thirdly, for the *Manner* of their *Appearance.* I have ſeen many 'Spots, which in the middle of the Sun appear of a round Body, but 'coming towards the Side of the Sun, appear long. Which is a de- 'monſtrative Argument, that they are not Globes, as all the Planets 'and Stars are: For Globes always appear of one Form (round) in 'every Poſition; but Exhalations, or ſuch like fluid Subſtances, ex- 'tended to a broad flat Form, like our Clouds, which being over our 'Heads, and ſo in their full breadth, appear large and broad; but 'driven with the Wind, till they turn one Edge upon us, ſeem of a 'long Shape. So theſe ſolar Clouds, being turned about the Sun, may 'in the middle ſhew their full Breadth to us, and about both Edges 'of the Sun, turn their Edges to us: Which anſwereth to the Ap- 'pearance.

'Fourthly, for their *Continuance.* Some of theſe Spots, ariſing at 'the Eaſt-ſide of the Sun, vaniſh before they come to the midſt of the 'Sun. Others appear firſt in the middle of the Sun, and vaniſh be- 'fore they come to the Weſtern Limb; and for the moſt Part they 'vaniſh, before they have made a full Revolution about the Sun. Which 'argues them to be but thin, vaniſhing, fading Subſtances, not like 'the permanent Bodies of the Stars.

'But to take off theſe Reaſons, you anſwer, That you conceive 'theſe Spots to be Stars moving regularly in their own Orbs, which

'are

‘ are many, though none of greater Extent than about $\frac{1}{10}$ of the ☉ Se-
‘ midiameter from its Circumference; and that the ſwifter Movers in
‘ the lower Orbs, overtaking the ſlower in the higher Orbs, cauſe an
‘ Appearance. You ſeem therefore to think, that they being ſo thin
‘ Bodies, the Sun's Rays paſs through them, and ſo one cannot be ſeen
‘ alone, till more being together, one heaped behind another, they
‘ ſtop the Light of the Sun's Rays, and ſo cauſe an Appearance. This
‘ I conceive is your Meaning: Or elſe (as you ſeem to inſinuate after-
‘ wards) that the higher reflects the Sun's Rays ſtrongly enough upon the
‘ lower (when they come within the Angle of Reflection) to make the
‘ interjacent Planet indiſcernible.

‘ But to theſe I anſwer, that

‘ 1. ‘ If it be by their coming within the Angle of Reflection, that
the Light of the Sun reflected from the outer Planet upon the inner,
‘ doth make it (as you ſpeak) indiſcernible, then that Light ſo re-
‘ flected is reflected either upon all Places, as the Moon and Planets
‘ Light; or but upon one, as is the Reflection of a plain Looking-
‘ Glaſs. If the *Firſt*, there would never be many ſeen (ſeldom above
‘ one or two) becauſe the outermoſt would continually make the inner
‘ undiſcernible. But *Gaſſendus* affirms, there are ſeen ſometimes 40
‘ at once in the Sun's Body. If the 2d, there would always be many
‘ ſeen, becauſe the reflected Light would but occupy a little Room,
‘ and that but for a ſmall time, till the ſwifter were paſt the Place of
‘ Reflection: Whereas many Days there are none at all ſeen in the
‘ Sun's Hemiſphere: And in both theſe Caſes, the outermoſt Planet
‘ of all would always in the Space of 27 Days, be ſeen in the ſame
‘ Place, being never obſcured, none of the Inferior being able to re-
‘ flect Light upon it. Add hereunto, if any Kind of Reflection ſhould
‘ make them to appear bright like the Sun, and ſo not diſtinguiſhable
‘ from the Light of the Sun, what ſhould [a] hinder, but we ſhould ſee
‘ them alſo bright Bodies by the Side of the Sun, when they are paſ-
‘ ſing either by the Weſt, or Eaſt-ſide of the Sun's Body? The Light
‘ being then reflected upon them by the inferior Planets, as well as at
‘ other times, and that alſo upon much of that Side of them which we
‘ ſhould behold.

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[a] N. B. *Mr.* Gaſcoigne *having, againſt theſe Words, inſerted a rough-drawn Figure in the Margin of Mr.* Crabtrie's *Letter, I have alſo repreſented it in* Fig. 118. *imagining it may ſomewhat explain Mr.* Gaſcoigne's *Hypotheſis, and what Mr.* Crabtrie *ſaith againſt it.* Fig. 118.

'But if you wave this Conceit, as inſufficient, and fly to your former, That the ſwifter Movers in the lower Orbs, overtaking the 'ſlower in the higher Orbs, cauſe an Appearance. To this I anſwer: '1. The thing you ſuppoſe ſeems to me neither neceſſary nor probable, 'nor do I conceive, why they ſhould not be ſeen, being themſelves 'alone, as well as conjoined, ſeeing all other Stars and Planets are ſo. '2. If it be, becauſe they are of a thin, tranſparent Subſtance, till 'many, being one behind another, make them to ſeem groſſer; then 'they are not of the Nature of other Planets, as is proved in ☿ and ♀, 'who of themſelves appear dark Bodies, when they come between us 'and the Sun; nay, they muſt be more thin than our Clouds, which 'will eaſily be ſeen between us and the Sun, and hide it from us. 3. If 'it be, becauſe they are ſo little, that the Imperfection of our Glaſſes 'cannot diſcover one alone, there muſt be, without doubt, many Millions of them; which how they can be included within the compaſs 'of $\frac{1}{10}$ of the ☉ Semidiameter, we ſhall conſider anon. I have ſeen one 'of an ordinary Darkneſs, (yea darker than many greater) yet not 'above 5″ Diameter. If this conſiſt of two, or many, of themſelves 'inviſible, how many were in thoſe which *Gaſſendus* ſaw of $1' \frac{1}{2}$ Diameter? 4. The Figure of theſe great ones (being neceſſarily compoſed 'of Stars of ſuch different Orbs and Motions) would quickly vary, 'by reaſon of the Diverſity of their Motions; like as we ſee in a Flock 'of ſmall Birds. But 5thly, you ſay the furtheſt of theſe Orbs is not 'above $\frac{1}{10}$ of the Sun's Semidiameter from its Circumference. But 'there would not, in that ſmall Space, be room enough for ſo many 'Orbs of Planets, as have been ſeen at once. Which I prove thus: '1. *Gaſſendus* affirms, there are ſometimes ſome of about the $\frac{1}{10}$ Part 'of the ☉ Semidiameter; which is the whole Space allowed by you 'for them all. And myſelf have ſeen of the $\frac{1}{15}$ of the ☉ Semidiameter: 'And yet you muſt confeſs, theſe great ones could only be Conjunctions 'of ſome, not all. 2. There are many times ſeen in the Sun's Superficies, a great Number of Spots, whoſe Diameters added together, 'would do more, than twice fill the Space you ſpeak of. I myſelf have 'ſeen it, and ſo I believe have you. *Gaſſendus* affirms, there are ſometimes 40 ſeen at once: If this was by Conjunction of Planets, in every 'Appearance, there were at leaſt 80 Bodies at once on this Side the ☉; 'it may be as many on the other Side, beſides thoſe unſeen (by your 'Reflection or otherwiſe) which doubtleſs muſt be far more than ſeen. 'For it is a moſt rare, and I think unheard of thing to ſee but 3 (which 'is leſs than the half) of our Planets, conjoined in viſible ☌ at once: 'So that without queſtion, if they be Planets, they are many hundreds; which muſt have ſo many ſeveral Orbs, and which certainly 'cannot be done in ſo narrow a Compaſs, as the $\frac{1}{10}$ of the ☉ Semidiameter. And that they cannot have any larger (I ſuppoſe not ſo

'large

'large an) extent from the ☉ Superficies, may be proved by their Motion through the viſible Hemiſphere of the Sun's ſpherical Body, by comparing the ſwiftneſs of their Motion towards the middle and Sides together. 6. If one of theſe (imagined) Planets be ſwifter than another, as they muſt needs be, then the ♂ of 2 or 3 ſwifter ones would make a Spot of ſpeedier Motion than the ♂ of 2 ſlower ones: But the Motion of all about the ☉ Center, is always equal; yea, and the Spots retain the ſame Poſition one to another, (conſidering the Sun's Sphericity, and the Angle of their Appearance to us) juſt like the fixed Stars. So affirms *Gaſſendus*, *Moveri omnes eodem & uniformi motu, adeo ut, cum plures fuerint, nulla antevertat aliam, ſed eundem tenorem in diſco ☉ perinde ſervent inter ſe, ac ſervant Fixæ in firmamento.*

'As for that other *annual Motion* of the Spots, you ſpeak of, from Weſt to Eaſt, upon their Axis inclined above 8 Degrees to the Ecliptick; I ſuppoſe it is not any real Motion of the Orbs of thoſe ſolar Planets or Spots, but only a viſible Motion ſo appearing, cauſed (in *Kepler*'s Syſtem) by the Sun's rolling upon its own Center in the midſt of all the Orbs, and not exactly in the way of the *Temporary* Ecliptick, but in the *Via regia* (as *Kepler* calls it) inclined certain Degrees to the *Temporary*; thereby turning about with him, the ſame way, his adventitious, or excrementitious Parts, the Spots, by his *magnetical* or *ſympathetical Rays*. And hence may be demonſtrated the Appearance of that annual Motion in the Sun's Spots you ſpeak of. See *Galilæus*, *Syſt. Coſm. p.* 339, *& ſeq.* So alſo in *Ptolomy*'s and *Tycho*'s Syſtem, the ſame Appearance may be demonſtrated, ſuppoſing the ⊖ fixed in the middle of the Univerſe, and the ⊙ rolling round upon the ſame Poles of that *Via regia* (or way of the Spots) and keeping his Axis in Paralleliſm continually towards one and the ſame Part of the Univerſe. This may be certainly demonſtrated, although *Galilæus* there affirms the contrary. Other *Hypotheſes* of that Motion may be feigned, as by the annual Converſion of the Poles of the *Via regia* about the Poles of the Ecliptick in the Sun's Body: But none I conceive ſo compendious, as the one of the former. For my Part, I incline to the firſt.

'Thus you have, what for the preſent, I conceive of theſe *Maculæ Solares*. *Fromundus* mentions one *Jo. Tarde Gallus*, who thinks them to be ſecondary Planets; who hath written a Book of that Subject, and calls them *Aſtra Borbonia:* But I could never yet ſee it. What you, or he, or others may alledge for that Opinion, I know not. In the mean time I cannot acknowledge them Stars, unleſs I ſee at leaſt ſome Poſſibility how they may be ſo, or ſome Probability why they ſhould not rather be Spots. Which when you, or they do produce from better grounded Reaſons, Optical Experiments, or Demonſtrations, I ſhall willingly recant my Opinion.

Of the Diameter *of* Venus.

'It is true which you ſay, That I found *Venus*'s Diameter much leſs 'than any Theory extant made it. *Kepler* came neareſt, yet makes her 'Diameter 5 Times too much. *Tycho*, *Lanſberge*, and the Ancients, 'about 10 Times greater than it was. So alſo they differ in the Time 'of the ☌ as far from the Truth. By *Lanſberge* the ☌ ſhould have 'been 16^h 3′ before we obſerved it: By *Tycho* and *Longomontane* 1^d 8^h '25′ before. By *Kepler* (who is ſtill neareſt the Truth) 9^h 40′ before. 'So that had not our own Obſervations, and Study, taught us a better 'Theory than any of theſe, we had never attended at that Time for 'that *rare Spectacle*. You ſhall have the Obſervation of it, when we 'ſee you. The Clouds deprived me of Part of the Obſervation, but 'my Friend Mr. *Jeremiah Horrox*, being near *Preſton*, obſerved it 'clearly from the Time of its coming into the Sun, till the Sun's ſet-'ting; and both our Obſervations agreed, both in the Time and Dia-'meter, moſt preciſely.

'*Langsberge* in Eclipſes, eſpecially of the ☽, comes often nearer the 'Truth than *Kepler*, yet it is by packing together Errors; his Diame-'ter of the ☉ and ☽ being falſe, and his Variation of the Shadow be-'ing quite repugnant to Geometrical Demonſtration. His circular 'Hypotheſis Mr. *Horrox* (before I could perſuade him) aſſayed a long 'Time with indefatigable Pains and Study to correct, and amend; 'changing and turning them every way (ſtill amazed and amuſed with 'thoſe lofty Titles of Perpetuity and Perfection, ſo impudently im-'poſed upon them) until we found, by comparing Obſervations in ſe-'veral Places of the Orbs, that his Hypotheſes would never agree with 'the Heavens for all Times, as he confidently boaſts; no, nor ſcarce 'for any one whole Year together, alter the equal Motion, Proſtha-'phæreſes, and Excentricity howſoever you will.

'*Kepler*'s *Elliptick* is undoubtedly the way which the Planets deſcribe 'in their Motions: And if you have read his *Comment. de motu* ♂*is*, and 'his *Epit. Aſtron. Copern.* I doubt not you will ſay his Theory is the 'moſt rational, demonſtrative, harmonious, ſimple, and natural, that 'is yet thought of, (or I ſuppoſe can be;) all thoſe ſuperfluous Fictions 'being rejected by him, which others are forced ſo abſurdly to intro-'duce. And although in ſome reſpects his Tables be deficient, yet be-'ing once corrected by due Obſervations, they hold true in the reſt: 'Which *Lanſberge*'s and all others want.

'Your Conceit of turning the Circle into 100,000,000 Parts, were 'an excellent one, if it had been ſet on foot, when Aſtronomy was 'firſt invented. Mr. *Horrox* and I have often conferred about it. But 'in reſpect that all Aſtronomy is already in a quite different Form, and 'the tedioufneſs of reducing the Tables of Sines, Tangents, and all 'other things we ſhould have occaſion to uſe, into that Form; as alſo 'ſome Inconveniences, which we foreſaw would follow in the compoſing 'the Tables of Celeſtial Motions, together with the greatneſs of the

'Innova-

‹ Innovation, deterred us from the Conceit. Only we intend to uſe ‹ the Centeſmes or Milleſmes of Degrees, becauſe of the Eaſe in Calcu- ‹ lation. I have turned the *Rudolphine* Tables into Degrees and Mil- ‹ leſmes, and altered them into a far more conciſe, ready, and eaſy ‹ Form, than they are done by *Kepler*.

Foraſmuch as every thing of Mr. *Crabtrie*'s is valuable, I have taken this Occaſion from my own Obſervations of the ſolar Spots (for the moſt Part drawn up near four Years ago) to give Mr. *Crabtrie*'s Letter at large (which I ſaw not till about a Month ago) containing as well ſome things of another Nature, as what relates to the Spots; I have two other of his Letters concerning the Spots (with Mr. *Gaſcoigne*'s Anſwers.) One contains his Theory of their Motion and Appearances; the other his Way of obſerving them. But being long, I ſhall omit them for the preſent.

Fig. 115. *Shows the Stages and Lines deſcribed by the* Spots *upon the* Sun *in* Sept. *and* Novemb. 1706. *and in* Feb. *and* March, $170\frac{6}{7}$. *and in* Sept. *and* Novemb. 1707. Fig. 115.

Fig. 116. *Shows the Stages and Lines deſcribed by the* Spots *upon the* Sun *in* Jan. $170\frac{3}{4}$. *and in* May, June, *and* Octob. 1705. Fig. 116.

XI. On the 12th of *June* 1694. in the Morning, I went to the College at *Cambridge*, about four Miles from *Boſton*, and obſerved with the Braſs Quadrant there, with Teleſcopick Sights, the Rays of the Sun being tranſmitted through one of the ſaid Sights, on a clean Paper, paſted on a plain Piece of Board, and faſtned at right Angles at about a Foot diſtance from the ſaid Sight, on which Paper I had drawn a Circle between 2 and 3 Inches Diameter, equal to the Sun's Diſk, and within that ſeveral Concentric Circles dividing the Diameter into 24 equal Parts, whereby I could obſerve to $\frac{1}{2}$ a Digit: The Room in which the Obſervation was made, was darkened with Blankets, and in order to render the Obſervation more exact (Mr. *Henry Newman* aſſiſting me all the while) I took the Altitude of the Sun with the foreſaid Quadrant, as followeth. *Eclipſe of the* Sun, June 12. 1694. *in* New-England, *by Mr.* T. Brattle, n. 292. p. 1630.

Obſervations made of the Sun's Altitude before the Eclipſe began, in order to rectify the Watch.

	By the Watch				Comp. Altit.			Time by Calcul.			Differ.	
	h	′	″									
at	8	26	37	Mane	49	31		8	16	40	9	57
		31	27		48	26			21	40	9	47
		38	26		47	20			28	32	9	54

The Eclipſe was firſt perceived at h 9 ′ 25 by the Watch, at which time the Sun had ſcarcely been eclipſed 1 Minute, ſo that

By

By the Watch h	′		True time. h	′	
9	24		9	14	It began
9	32		9	22	about 1 digit eclipſed
9	48		9	38	full 3 digits
9	57¼		9	48	about 4
10	06		9	56	near 5
10	15		10	05	full 6
10	33		10	23	about 8
10	43		10	33	full 9
10	47		10	37	full 9½
10	53		10	43	full 10
10	59		10	49	about 10½
11	03		10	53	better than 10½
11	06		10	56	much the ſame
11	09		10	59	rather decreaſing
11	10½		11	00½	ſenſibly decreaſed near ¼ of a digit
At 11	14½		11	04½	neareſt to 10 digits
11	25		11	15	full 9 digits, *i. e.* full 3 digits reſtored, or the Shadow rather within 9 digits
11	29		11	19	8½ compleat
11	34½		11	24½	full 8 digits
11	44		11	34	full 7
11	48		11	38	full 6½ digits
11	52½		11	52½	juſt 6
0	02½	P. M.	11	32½	juſt 5
0	13		0	03	P. M. full 4
0	26		0	16	full 2½
0	32		0	22	better than 2
0	41		0	31	better than 1
0	48		0	38	ended.

Obſervations made after the Eclipſe was done, of the Sun's Altitude, in order to rectify the Watch.

	Time by the Watch h	′	″		Comp. Altit.		True time.		Differ.
	3 31	30		45	52	3 21	36	9	54
	36	15		46	23	26	16	9	59
At	38	10	P.M.	46	45	28	16	9	54
	46	50		48	19	36	48	10	02
	48	10		48	30	38	20	9	50

Hence

Hence it appears, that the Watch went about 10 Minutes too faſt during the whole Eclipſe, as we have all the way allowed.

So that the Eclipſe

	h	′	
Began at	9	14	Mane.
Ended	0	38	P. M.
Laſting in all	3	24.	

Note, That in the Calculation, the Latitude of *Boſton* was allowed to be 42 . 25′.

XII. At half an Hour paſt 8 in the Morning, I ſet my Clock exactly by my Ring-Dial, and at half an Hour paſt 9 they nicely agreed, at

Eclipſe of the Sun, *Nov.* 23. 1703. *in* New England, *by the* ſame, *ibid.* p. 1634.

h	′	
10	00	The Sun was not touch'd.
	06	The Moon enter'd on the SSW Point as near as I could judge.
	15	The Eclipſe was conſiderably advanc'd.
	20	ſeem'd to be about half a digit eclipſed, rather more than leſs, and the Section to be a ſmall matter more Weſtwardly.
10	25	Much the ſame, and near the ſame Point.
	30	ſeem'd to be leſs.
	33½	The middle of the Section nearer the SW, and the Diameter of the Section leſs every way.
	37½	Much leſs and nearer the Weſt.
	44½	It ended, and was juſt over, going off near the SW, ſo that all the while it was within a Point or two of the Place where it firſt came on, or between the SSW and the SW.

I judg'd, when it was at the Height, that the Chord of the eclipſed Part was neareſt equal to the Side of an inſcrib'd Decagon, or ſubtended about $\frac{1}{10}$ of the Periphery of the Sun's Diſk.

I obſerv'd this Eclipſe with a Teleſcope of one Joint, 4 Foot and a half in Length, and had only 2 Glaſſes, ſo that it inverted the Object; and I had a red Glaſs, which ſuited it, ſo that I could ſcrew it in juſt before the Eye-Glaſs, and was not fain to hold it in my Hand, as when I obſerv'd the Sun's Altitude with the Braſs Quadrant, which was a great Convenience.

XIII. 1.] The Morning was cloudy and moiſt, till about eight a Clock, when the Clouds began to break, and we had ſometimes a Sight of the Sun thro' the Spaces betwixt them. A ſeven-foot Teleſcope was fitted up with a Scene to receive the Species of the Sun caſt through it, and on which it was about ſeven Inches Diameter, divided

Eclipſe of the Sun, May 12. 1706. *at* Greenwich, *by Mr.* Flamſted, n. 306. p. 2237.

divided into Digits by ſix concentrick Circles. But Clouds covering the Sun frequently rendred this way of obſerving inconvenient, and therefore laying aſide the *Apparatus* of the Scene, I viewed him through the Teleſcope with ſmoaked Glaſſes, to ſave my Eyes, and noted

Correct time by the Pend. Clock. h	′	″	
8	21	30	A very ſmall Part of the ⊙ Diameter was eclipſed.
	28	00	The Chord of the Arch of the ⊙ Periphery eclipſed was 14′. 40″. then followed frequent Clouds through the Spaces betwixt; then ſome Zenith Diſtances of the Sun were taken for correcting the Clock, and afterwards near the middle of the Eclipſe
9	21	46	The Parts of the Diameter remaining clear 5 00
	26	20	——— 4 30
10	31	50	Frequent large Clouds again, till the Sun appeared through the Breaks, and we ſaw the Eclipſe was not ended. Clouds again till
10	33	50	When the Sun ſhone out again, we ſaw his Limb intire, and the Eclipſe certainly over.

— *at* Canterbury, *by Mr.* S. Gray, *ibid.*

2.] Mr. *S. Gray* had prepared a Scene placed behind his ſeven Foot Glaſs, ſo that the Species of the Sun projected on it was ſeven Inches over; but having the ſame ſort of Weather that was at *Greenwich*, he ſaw not the Beginning, by reaſon of Clouds, but other Phaſes with the End he noted, as follows.

Correct time by the Pend. Clock. h	′	
8	53	digits 5 ½ darkned
9	08	——— 7
	31	——— 10 or more
	36	——— The Sun ſhining for a ſhort time, the Eclipſe ſeem'd to decreaſe.
	55	——— 7 ½ a little clearer.
	57	——— 6 ¾
10	02	——— 6
	04	——— 5 ¾
	14	——— 4
	16	——— 3 ¾
	20	——— 2 ½
	30	——— 1
	31	——— 0 ¾
10	36 ½	The End accurately with a Tube of 16 Foot.

3.] Mr. *Abr. Sharp* caſt the Species of the Sun on a Scene-plate, behind his ſeven Foot Glaſs, ſo as it appeared 7 Inches over. By reaſon of cloudy Weather, he ſaw neither the Beginning nor End: But other Phaſes near the middle, as follows.

— *at* Horton *near* Bradford *in* Yorkſhire, *by Mr.* A. Sharp, *ibid.*

Time correct by the

h	′	″			
8	35	00	digits dark	3	} by Ocular Eſtimation.
9	01	00		7	}
	4	54		8	$\frac{1}{10}$ Eclipſed on the Scene.
	6	33		8	$\frac{1}{2}$
	7	53		8	$\frac{4}{10}$
	12	50		9	
	16	08		9	$\frac{4}{10}$
	18	48		9	$\frac{1}{2}$ exactly, the ⊙ ſhining out clear.
	20	45		9	$\frac{1}{2}$ the ⊙ ſtill ſhining clearly. Greateſt Obſcurity.
	21	48		9	$\frac{1}{2}$ ſtill clear.
	28	46		9	
	44	45		7	
	54	42		5	$\frac{1}{4}$
10	06	10		3	$\frac{1}{2}$
	19	55		1	preciſely.
	24	00	The ⊙ ſeen thro' Clouds, the Eclipſe not ended.		
	30	00	The ⊙ ſeen again perfectly round and intire.		

4.] Captain *Stannyan*, from *Bern* in *Switzerland*, writes ‘ That the ‘ Sun was totally darkned there for 4 $\frac{1}{2}$ Minutes of Time; that a fixed ‘ Star and a Planet appeared very bright; and that *his getting out of ‘ the Eclipſe was preceded by a Blood-red Streak of Light, from its Left ‘ Limb; which continued not longer than* 6 *or* 7 *Seconds of Time*; then ‘ Part of the Sun's Diſk appear'd, all on a ſudden, bright as *Venus* ‘ was ever ſeen in the Night; nay, brighter; and in that very inſtant ‘ gave a Light and Shadow to things, as ſtrong as Moon-light uſes ‘ to do.

— *at* Bern *in* Switzerland, *by Capt.* Stannyan, *ibid.*

The Captain is the firſt Man I ever heard of, that took Notice of a red Streak of Light preceding the Emerſion of the Sun's Body from a total Eclipſe: And I take Notice of it, becauſe it infers that *the Moon has an Atmoſphere*; and its ſhort continuance of only 6 or 7 Seconds of Time, tells us, that *its Height is not more than the* 5 *or* 6 *hundredth Part of her Diameter.*

— *at* Geneva, *by Mr.* J. C. Facis *Duillier*, ibid.

5.] A little after the Sun's riſing, the Sky did ſeem clear; tho' the Air was thick already with ſome Vapours. Many little Clouds did afterwards ariſe here and there, and the Vapours did much increaſe. For want of a Pendulum Clock, in a convenient Place, the Moment of the *total* Immerſion, the Moment of the *firſt* Emerſion, and that of the *End* of the Eclipſe, could not be accurately obſerved. Tho' the Sky was ſomewhat overcaſt, the Heat of the Sun was already felt, when the Eclipſe did begin: But a very ſenſible Coldneſs took Place, as the Moon did by degrees cover a greater and greater Part of the Sun, and the Light decreaſe. The Eclipſe was obſerved only with ſome Glaſſes, either darkned with Smoak, or but little tranſparent; and by receiving the Sun's Image through a ſix Foot Teleſcope, which repreſented the Objects inverted, upon a white Paper, placed at ſome Diſtance, from the Eye-Glaſs. When the Sun was near being totally dark, the bright Creſcent, which did remain, was ſeen to diminiſh more and more, upon the Paper, where its Image was received. And when that Creſcent was reduced to a very narrow Breadth, and to a very little Length, it was ſeen on a ſudden to diſappear: And in that Moment the whole Sun was eclipſed. At the ſame Inſtant of time, the Darkneſs, which was already very conſiderable, did become much greater. The Clouds did change on a ſudden their Colour, and became red, and then a pale Violet. There was ſeen, during the whole time of the total Immerſion, a Whiteneſs, which did ſeem to break out, from behind the Moon, and to encompaſs it on all Sides equally. The ſame Whiteneſs was but little determined, in its outward Side, and was not broad the twelfth Part of the Diameter of the Moon. This Planet did appear very black, and her Diſk very well defined, within the Whiteneſs, which encompaſſed it about, and whoſe Colour was the ſame with that of a white Crown, or *Halo*, of about four or five Degrees in Diameter, which accompanied it, and had the Moon for its Center. The Star of *Venus* was ſeen, at the ſame time, at ſome Diſtance, without that Crown, between the Eaſt and N. E. in reference to the Sun. The Planets of *Saturn* and *Mercury* were ſeen alſo by many, Eaſtward from the Sun's Place. And if the Sky had been clear, many more Stars might have been ſeen, and with them the Planets of *Jupiter* and *Mars*; that towards the Eaſt, and this towards the Weſt: And ſo the ſeven Planets might have been ſeen, almoſt all at once. Accordingly ſome Gentlewomen being in the Country, did tell, as it is ſaid, more than ſixteen Stars. And many People, which were on the Neighbouring Mountains, did ſee the Sky ſtarry, in ſome Places, where it was not overcaſt, as during the Night, in the time of the full Moon. The total Immerſion did begin about three Quarters paſt Nine. The Duration of the total Darkneſs was preciſely three Minutes, or 180 Seconds, to the Moment that the firſt Ray of the Sun did begin to appear again, with much

Brightneſs. And this time was obſerved, with a ſimple Pendulum; which was afterwards compared with a Pendulum Clock, ſhewing the Seconds, and regulated upon the mean Motion of the Sun. A little after the Sun had begun to appear again, the Whiteneſs and the Crown, which did encompaſs the Moon, did entirely vaniſh. The Sun did then ſhew itſelf more and more; appearing at firſt as a little Creſcent, which did ſtill encreaſe; and whoſe concave Side did ſeem terminated, as by an Arch, deſcribed with the Compaſs. A little before the total Obſcuration, the Country, on the Weſt Side, did already ſeem overcaſt with Darkneſs; and after the total Obſcuration, the Darkneſs was ſeen to leave us more and more, and to fly Eaſtward. According to Mr. Profeſſor *Gautier*'s Obſervations, from the firſt Emerſion of the Sun, to the End of the Eclipſe, there was $1^h\ 9'\ 30''$. As to the accurate times they are uncertain, the Pendulum Clock having been ſet only by a ſmall Sun-Dial. I ſend you alſo the following Account, which the ſame Gentleman did communicate to me.

	h	′	″	
6.] ‘ At *Marſeilles*, the Eclipſe did begin at ——	8	28	40	— *at* Marſeilles *by Mr.* Chazelles, *and Father* Laval, *ibid.*
‘ It did reach the Sun's Center at ——	9	6	11	
‘ It was total at ——	9	34	15	
‘ The Sun did begin to appear again at ——	9	37	9	
‘ The Eclipſe did come again to the Center at ——	10	12	23	
‘ It did entirely end at ——	10	47	50	

‘ Three Stars were diſtinctly ſeen; and during three Minutes it was ‘ not poſſible to read. And there did remain one bright Digit, all ‘ about the Globe of the Moon.

The Manor Houſe of *Duillier* is in the Latitude of $46^\circ\ 24'$. In Longitude it is $4^\circ\ 13'\ 45''$ to the Eaſtward of the *Royal Obſervatory* at *Paris*. And St. *Peter*'s Church at *Geneva* is, in Latitude, $0^\circ\ 12'$ to the Southward, and in Longitude, $0^\circ\ 5'\ 2''$ to the Weſtward of *Duillier*.

Before I make an end, I muſt take Notice, that, according to theſe Obſervations, the Altitude of the Moon's Atmoſphere cannot well be ſuppoſed leſs than of 130 Miles, in perpendicular Height: Of which Miles 60 go to one Degree of Earth. Neither could that Atmoſphere be diſcovered, before the time of this Eclipſe, by any Refraction of the Stars: Probably becauſe of this Refraction's ſmallneſs; and for want of proper Obſervations. And though it was very plain that the Atmoſphere of the Moon muſt needs ſhew itſelf, in the time of a total Eclipſe of the Sun; yet I do not know, that any Body did think of this, till, in the laſt Month of *May*, many Perſons did actually ſee it.

Some

Some particular Obſervations, which are intended to be made publick, do evince that our Atmoſphere is ſometimes viſible, all along, from the Surface of the Earth to the perpendicular Height of one Semidiameter of the Terreſtrial Globe. And the continued Appearance of a Crown, of only four or five Degrees Diameter, about the Sun, during the whole Time of the total Obſcuration, does ſhew that the Æthereal Matter, in which that Crown was produced, muſt be at a very great Height above the Surface of the Earth. But if that Crown was to be ſeen, ſo far as the Weather did permit, in all the Places, where the Eclipſe was total, it muſt be concluded, that the Cauſe of it was not in our Air, but in ſome Vapours incompaſſing the Sun: And probably, in thoſe very Vapours, which produce that pointed Light, that has been obſerved lying in a manner along the Ecliptick, and that has the Sun for Center. Now either of theſe Concluſions, *viz.* concerning the great Height of the Parts of our Atmoſphere, capable of producing that Crown, or elſe concerning a Meteor obſerved, not in our Air, but in the Vapours that encompaſs the Sun, is very ſingular, and deſerves a great deal of Attention. If ever ſuch another Appearance ſhould be ſeen, in the time of a total Eclipſe, it would be proper to obſerve accurately the leaſt Diameter of the Crown, from inſide to *inſide:* And to take Notice, whether during the whole time of the total Immerſion, the inward Circle be every where continued, and of an uniform Figure. The leſs the ſaid Diameter, and the greater the Exceſs of the Moon's apparent Diameter above that of the Sun; as alſo the greater the apparent Altitude of the Sun is above the Horizon; the higher the Cauſe, which produces the Crown, muſt be above the Surface of the Earth. And the Poſition upon the Moon's Diſk, in reference to the Zenith, of the Points of Contact, where the Sun diſappears, or begins to ſhew itſelf again, is here alſo of ſome Conſideration.

— *at* Zurich *by Dr.* J. J. Scheuchzer.

7.] Habuimus hic, die 12°. *Maii* Eclipſin Solis totalem ſimul & annularem, totalem quoniam Sol integer à Lunâ fuit obtectus; annularem autem non propriè ita dictam, ſed per Refractionem, quandoquidem circa Lunam fulgor apparuit rutilans, à radiis per Atmoſphæram Lunæ refractis ortus.

Fig. 119.

Initium Eclipſeos fuit mane horâ	8.	54′.
Medium horâ	9.	58′.
Finis horâ	11.	12′.
Mora mediæ & plenæ obſcurationis		4′.

Quâ viſæ fuerunt Stellæ tam fixæ, quàm erraticæ; ad nidos ſuos ſeſe receperunt Aves; prodiere è latebris ſuis Veſpertiliones, & Aquæ innatârunt Piſces: Nos autem experti ſumus ſenſum frigoris manifeſtum; & in Plantas decidit Ros.

XIV.

The Corr. App. Time.		
h	′	″
6	44	15
8	31	15
8	32	45
8	35	45

XIV. The Beginning of the Eclipſe we could not ſee for Clouds.

Eclipſe of the Sun, *Sep.* 3. 1708. *at* Upminſter, *by Mr.* Derham, n. 320. p. 312.

The Sun peeped out of the Clouds, and I judged, by my Eye, that about one Tenth of a Digit was eclipſed.
Then Clouds nearly all the Time of the Eclipſe. But at
A little Obſcuration appeared through the Teleſcope.
A *very* little Obſcuration, through the Teleſcope.
Then Clouds. And at
We could diſcern no remains of the Eclipſe through the Teleſcope.

From theſe Obſervations I imagine the End of this Solar Eclipſe was much about 8 h. 33′ in the Morning.

XV. 1. Though it be certain from the Principles of Aſtronomy, that there happens neceſſarily a Central Eclipſe of the Sun, in ſome Part or other of the Terraqueous Globe, about twenty-eight Times in each Period of eighteen Years; and that of theſe, no leſs than eight do paſs over the Parallel of *London*, three of which eight are Total with continuance: Yet, from the great Variety of the Elements, whereof the *Calculus* of Eclipſes conſiſts, it has ſo happened, that ſince the 20th of *March*, *Anno Chriſti* 1140, I cannot find that there has been a Total Eclipſe of the Sun ſeen at *London*, though in the mean Time the Shade of the Moon has often paſt over other Parts of *Great Britain*.

Obſervations of the Total Eclipſe *of the* Sun, *April* 22. 1715, *at* London, *by Dr.* E. Halley, n. 343. p. 245.

Having found, by comparing what had been formerly obſerved of Solar Eclipſes, that the whole Shadow would fall upon *England*, I thought it a very proper Opportunity to get the Dimenſions of the Shade aſcertained by Obſervation; and accordingly I cauſed a ſmall Map of *England*, deſcribing the Track and Bounds thereof, to be diſperſed all over the Kingdom, with a Requeſt to the Curious to obſerve what they could about it, but more eſpecially to note the Time of Continuance of total Darkneſs, as requiring no other Inſtrument than a *Pendulum Clock*, and as being determinable with the utmoſt Exactneſs, by reaſon of the momentaneous Occultation and Emerſion of the luminous Edge of the Sun, whoſe leaſt Part makes Day. Nor did this fail of the deſired Effect, for the Heavens having proved generally favourable, we have received from ſo many Places ſo good Accounts, that they fully anſwer all our Expectations, and are ſufficient to eſtabliſh ſeveral of the Elements of the *Calculus* of Eclipſes, ſo as for the future we may more ſecurely rely on our Predictions: Though it muſt be granted, that in this our Aſtronomy has loſt no Credit.

Having

Having received the Orders of the Society to provide for the Obſervation to be made at their Houſe in *Crane Court*, I procured a *Quadrant* of near 30 Inches *Radius*, exceedingly well fixt with Teleſcope Sights, and moved with Screws, ſo as to follow the Sun with great Nicety; as alſo a very good *Pendulum Clock* well adjuſted to the mean time, and ſeveral Teleſcopes to accommodate the other Obſervers.

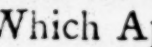
In order to examine both Clock and Quadrant, I, on the 20th of *April*, obſerved the Diſtance of the upper Limb of the Sun from the Zenith 36° 16′, and the next Day 35°. 58′; by which it appeared, that the Diſtances from the *Zenith* taken by this Quadrant, ought to be increaſed by about one Minute: And that Allowance being made, by many Obſervations taken before and after Noon on the ſaid 21ſt Day, the Clock was found to anſwer the apparent Time or Hour of the Sun with ſufficient Exactneſs, as not going above 10″. too faſt. The next Day, *April* 20°, juſt before the Eclipſe began, we took the Diſtances of the Sun from the Zenith, *viz.* at 7h. 42′. 52″ A. M. the correct Diſtance of the Sun's Center *à vertice* was 62°. 1′. 40″. at 7h. 45′. 48″. it was 61°. 34′. 40″. And again at 7h. 48′, 55″ it was 61°. 6′. 40″: Which with the given Declination of the Sun and Latitude of the Place, ſhew the true Times reſpectively to have been 7h. 42′. 38″, 7h. 45′. 35″. and 7h. 48′. 39″; all agreeing, that the Clock was only 14 Seconds too faſt, and had gained ſcarce any thing ſenſible in a Day's time: So that it might be entirely depended upon during the Continuance of the Eclipſe.

Having computed that the Eclipſe would begin at 8h. 7′, I attended ſoon after Eight, with a very good Teleſcope of about ſix Foot, without ſtirring my Eye from that Part of the Sun whereat the Eclipſe was to begin: And at 8h. 6′. 20″. by the Clock, I began to perceive a ſmall Depreſſion made in the Sun's Weſtern Limb, which immediately became more conſpicuous; ſo that I concluded the juſt Beginning not to have been above five Seconds before, that is, exactly at 8h. 6′. 00″. correct time.

From this time the Eclipſe advanced, and by Nine of the Clock was about ten Digits, when the Face and Colour of the Sky began to be changed from perfect ſerene azure blue, to a more duſky livid Colour having an Eye of Purple intermixt, and grew darker and darker till the total Immerſion, which happen'd at 9h. 9′ 17″ by the Clock, or 9h. 9′. 3″ true time. This Moment was determinable with great Nicety, the Sun's Light being extinguiſh'd at once; and yet more ſo was that of the Emerſion, for the Sun came out in an Inſtant with ſo much Splendor, that it ſurprized the Beholders, and in a Moment reſtored the Day, *viz.* at 9h. 12′ 26″. true time, after he had been totally obſcured for 3′. 23″ of time. And as near as I could eſtimate the Points on the Moon's Limb, where the laſt Particle of the Sun vaniſhed was about the middle of the *South Eaſt* Quadrant of her Limb, or about 45 Degrees from her *Nadir* to the Left-hand: And the firſt Emerſion was about ten Degrees below the Horizontal Line through the Moon's Center

Center on the Weſt-ſide and at 14 Minutes paſt Nine, correct time, I judged the Horns of the Eclipſe to have been exactly perpendicular, and by Conſequence, the Centers of the Sun and Moon to be in equal Altitude.

It was *univerſally* obſerved, that when the laſt Part of the Sun remained on his Eaſt-ſide, it grew very faint, and was eaſily ſupportable to the naked Eye, even through the Teleſcope, for above a Minute of time before the total Darkneſs; whereas on the contrary, my Eye could not endure the Splendour of the emerging Beams in the Teleſcope from the firſt Moment. To this perhaps two Cauſes concurred; the one, that the Pupil of the Eye did neceſſarily dilate itſelf during the Darkneſs, which before had been much contracted by looking on the Sun. The other, that the Eaſtern Parts of the Moon, having been heated with a Day near as long as thirty of ours, muſt of Neceſſity have that Part of its Atmoſphere replete with Vapours, raiſed by the ſo long continued Action of the Sun; and by conſequence, it was more denſe near the Moon's Surface, and more capable of obſtructing the Luſture of the Sun's Beams. Whereas at the ſame time the Weſtern Edge of the Moon had ſuffered as long a Night, during which there might fall in Dews, all the Vapours that were raiſed in the preceding long Day; and for that reaſon, that Part of its Atmoſphere might be ſeen much more pure and tranſparent.

About two Minutes before the total Immerſion, the remaining Part of the Sun was reduced to a very fine Horn, whoſe Extremities ſeemed to loſe their Acuteneſs, and to become round like Stars. And for the Space of about a Quarter of a Minute, a ſmall Piece of the Southern Horn of the Eclipſe ſeemed to be cut off from the reſt by a good Interval, and appeared like an oblong Star rounded at both Ends, in this Form  : Which Appearance could proceed from no other Cauſe, but the Inequalities of the Moon's Surface, there being ſome elevated Parts thereof near the Moon's Southern Pole, by whoſe Interpoſition, part of that exceedingly fine Filament of Light was intercepted.

A few Seconds before the Sun was totally hid, there diſcovered itſelf round the Moon a luminous Ring, about a Digit or perhaps a tenth Part of the Moon's Diameter in Breadth. It was of a pale whiteneſs, or rather Pearl Colour ſeeming to me a little tinged with the Colours of the *Iris*, and to be concentrick with the Moon; whence I conclude it the Moon's Atmoſphere. But the great Height of it, far exceeding that of our Earth's Atmoſphere; and the Obſervations of ſome who found the Breadth of the Ring to increaſe on the Weſt-ſide of the Moon, as the Emerſion approached; together with the contrary Sentiments of thoſe, whoſe Judgment I ſhall always revere, makes me leſs confident, eſpecially in a matter whereto I gave not all the Attention requiſite.

Whatever it was, this Ring appeared much brighter and whiter near the Body of the Moon, than at a Diſtance from it; and its outward Circumference, which was ill defined, ſeemed terminated only by the extreme Rarity of the Matter it was compoſed of; and in all Reſpects reſembled the Appearance of an enlightned Atmoſphere viewed from far: But whether it belonged to the Sun or Moon, I ſhall not at preſent undertake to decide.

During the whole time of the total Eclipſe, I kept my Teleſcope conſtantly fixt on the Moon, in order to obſerve, what might occur in this uncommon Appearance, and I ſaw perpetual Flaſhes or Coruſcations of Light, which ſeemed for a Moment to dart out from behind the Moon, now here, now there, on all Sides, but more eſpecially on the Weſtern Side, a little before the Emerſion: And about two or three Seconds before it, on the ſame Weſtern Side, where the Sun was juſt coming out, a long and very narrow Streak of a duſky, but ſtrong red Light, ſeemed to colour the dark Edge of the Moon, though nothing like it had been ſeen immediately after Immerſion. But this inſtantly vaniſhed upon the firſt Appearance of the Sun, as did alſo the aforeſaid luminous Ring.

As to the Degree of Darkneſs, it was ſuch, that one might have expected to have ſeen many more Stars than were ſeen at *London:* The three Planets, *Jupiter*, *Mercury* and *Venus* were all that were ſeen by the Gentlemen of the Society from the Top of their Houſe, where they had a free Horizon: And I do not hear that any one in Town ſaw more than *Capella* and *Aldebaran* of the fixed Stars. Nor was the Light of the Ring round the Moon capable of effacing the Luſtre of the Stars, for it was vaſtly inferior to that of the full Moon, and ſo weak, that I did not obſerve it caſt a Shade. But the under Parts of the Hemiſphere, particularly in the *South Eaſt* under the Sun, had a crepuſcular Brightneſs; and all round us, ſo much of the Segment of our Atmoſphere as was above the Horizon, and was without the Cone of the Moon's Shadow, was more or leſs enlightned by the Sun's Beams; and its Reflection gave a diffuſed Light, which made the Air ſeem hazy, and hindred the Appearance of the Stars. And that this was the real Cauſe thereof, is manifeſt by the Darkneſs being more perfect in thoſe Places, near which the Center of the Shade paſt, where many more Stars were ſeen, and in ſome, not leſs than twenty, though the Light of the Ring was to all alike.

During the time whilſt the Sun recovered his Light, ſeveral Altitudes were taken to examine the Regularity of the Clock's Motion, and tho' the Sun now roſe much ſlower than at the Beginning, yet they all conſpired within a very few Seconds, that the Clock went ſtill one Quarter of a Minute too faſt. And the End of the Eclipſe approaching, I attended the Moment thereof, with all the Accuracy I could, and concluded the complete Separation of the Sun and Moon at $10^h.\ 20'.\ 15''$ by the Clock, or exactly $10^h.\ 20'$ correct time.

Hitherto

Hitherto I exhibit only what myſelf ſaw, but there were with us a great many Members of the Society; and the Right Honourable the *Earl of Abingdon*, and the Lord Chief Juſtice *Parker* were of the Number: The latter of which ſhewed an uncommon Curioſity and Deſire of Exactneſs, his Lordſhip doing us the Honour to aſſiſt at moſt of the Obſervations made for determining the Error of the Clock, and did himſelf, at the Moment of the Emerſion from total Darkneſs, obſerve the Diſtance of the Planet *Jupiter* from the Zenith 48°. 29′. by which the time thereof is verified.

There were alſo preſent ſeveral Gentlemen of other Nations, and among them Monſieur *le Chevalier de Louville* and Mr. *Monmort*, both of them Members of the *Royal Academy* of *Sciences* at *Paris:* The firſt whereof came purpoſely to obſerve this Eclipſe with us, and having ſeen the Beginning applied himſelf to take Digits with his Micrometer, and to obſerve the Occultations of three Spots at that time ſeen in the Sun; and communicated the following Notes, *viz.*

	h	′	″	
At	8	28	20	Four Digits were eclipſed.
	8	32	57	The firſt and bigger Spot touched the Moon.
	8	33	18	The ſame was wholly hid.
	8	34	08	The firſt of the two leſſer Spots was hid.
	8	34	58	The Second of them was hid.
	9	36	01	Emerſion of the greater Spot.
	9	38	06	Emerſion of the firſt leſſer Spot.
	9	40	25	Emerſion of the ſecond leſſer Spot.
	10	20	04	The End of the Eclipſe.

And he determined the time of the total Darkneſs 3′. 22″, or one Second leſs than by my Account.

The Heavens were all the while very favourable to us, and there was very little or no Wind, and not ſo much as one Cloud interrupted our View from the Beginning to the End; but no ſooner was the Eclipſe over, but a great Body of Clouds hid the Sun for many Hours after.

Theſe Obſervations having been made with all the Care we could, are not, 'tis hoped, far from the Truth.

What we have received from other Places is as follows:

The Reverend Mr. *James Pound* Rector of *Wanſted* in *Eſſex*, gives the following Account of the principal Phænomena obſerved there; he being furniſhed with very curious Inſtruments, and well ſkilled in the Matter of Obſervation, and having rectified his Clock by ſeveral Altitudes of the Sun taken both before and after, *viz.*

	h	′	″	
At	8	6	37	The Eclipſe firſt perceived.
	9	9	28	The total Immerſion.
	9	12	48	The Emerſion.
	10	20	32	The juſt End of the Eclipſe.
	0	3	20	The Continuance of total Darkneſs.

The near Agreement of this Obſervation with our own (the Difference being only what is due to the Difference of the Meridians) makes us the leſs ſollicitous for what was noted at the *Royal Obſervatory* at *Greenwich*; from whence we can only learn, that the Duration of total Darkneſs was 3′. 11″.

The Reverend Mr. *William Derham*, Rector of *Upminſter* in *Eſſex*, aſſiſted by *Samuel Molineux*, Eſq; Secretary to his *Royal Highneſs* the *Prince*, and other Perſons of Quality, made the following Obſervations there, *viz.*

	h	′	″	
At	8	7	41	The Eclipſe began.
	8	33	46	The Moon touched the greater Spot.
	8	34	36	She touched the middle Spot.
	8	35	41	She touched the third Spot.
	9	10	58	The total Darkneſs began on a ſudden, and *Aldebaran* appeared.
	9	14	6	The Emerſion, or the End of total Darkneſs.
	0	3	8	Continuance of total Darkneſs.
	9	42	41	The third and laſt Spot diſcovered.
	10	21	45	The End of the Eclipſe, by a 13 ½ Foot Glaſs.

And a little before the Beginning of the Eclipſe, he found the greater and preceding Spot to be more Northerly than the Sun's Center 373 ½ ſuch Parts as the Sun's Diameter was 1647, and that it followed his Weſtern Limb 0′. 43″ of time: By which *data* the Situation of that Spot is well determined.

The Profeſſors of Aſtronomy in both Univerſities were not ſo fortunate: Dr. *Keill* by reaſon of Clouds ſaw nothing diſtinctly at *Oxford*, but the End, which he obſerved at 10ʰ. 15′. 10″. As to the total Darkneſs, he could only eſtimate it by the ſudden Change of the Light of the Sky; and reckoned its Continuance but 3′. 30″; which was certainly too little, the Center of the Shadow having without doubt paſt very near *Oxford*. And the Reverend Mr. *Cotes* at *Cambridge*, had the Misfortune to be oppreſt by too much Company; ſo, that though the Heavens were favourable, yet he miſs'd both the time of the Beginning of the Eclipſe, and that of total Darkneſs. But he obſerved the Occultations of the three Spots, *viz.* of the firſt and greateſt

greateſt at $8^h.\ 34'.\ 11''.$ of the ſecond at $8^h.\ 35'.\ 15''.$ and of the laſt at $8^h.\ 36'.\ 55''.$ He noted alſo the End of total Darkneſs at $9^h.\ 14'.\ 37''$, and the exact End of the Eclipſe at $10^h.\ 21'.\ 57.$

We have received ſeveral Accounts from ſome Places, which lay near the Track of the Center of the Shade, and which might have been very proper to determine the greateſt Continuance of the Darkneſs; as from *Plymouth*, *Exeter*, *Weymouth*, *Daventry*, *Northampton* and *Lynn-regis*, all agreeing that the whole Sun was obſcured at thoſe Places full four Minutes, and ſome of them rather more. But as theſe Obſervers give us no Account how they meaſured this time, it may well be ſuppoſed they took it in a round Number, and perhaps from Pocket Minute-Watches. What I think may beſt be relied on for this Purpoſe, are two correſponding Obſervations made, the one at *Barton* near *Kettering* in *Northamptonſhire*, where by the Obſervation of *John Bridges*, Eſq; Treaſurer of his Majeſty's Revenue of Exciſe, with a good Pendulum-Clock and all due Care, the whole Sun was hid no more than $3'.\ 53''.$ The other was by Mr. *John Whiteſide*, A. M. Keeper of the *Aſhmolean Muſeum* at *Oxford*, and a ſkilful Mathematician, who obſerved after the ſame manner, at *King's-Walden* in *Hertfordſhire* near *Hitchen*, that the total Eclipſe continued but $3'.\ 52''.$ Hence it follows that the Center of the Shade paſt near the middle between theſe two Places, which are but 30 Geographical Miles diſtant from one another, and ſituate near at right Angles to the way of the Shade, and therefore that the total Obſcurity, where longeſt, could laſt but about $3'.\ 57''$, or perhaps a Second or two more at *Lynn*, and leſs at *Plymouth*, the Velocity of the Progreſs of the Shade gradually decreaſing, and its Diameter increaſing as it paſt on to the Eaſtward. And this Situation of the middle Line is confirmed by an Obſervation made at the Seat of the Right Honourable the Lord *Foley* at *Witley* eight Miles beyond *Worceſter*, by his Order, and communicated by his Lordſhip to the Society; whereby it appears that the total Darkneſs laſted there $3'.\ 15''.$ Hence it follows that *Witley* was about three or four Miles farther from the Center of the Shade on the North-ſide than *London* on the South: And *Witley* being, by *Ogilby's* Menſuration, 118 meaſured Miles from *London*, it is plain that the Center paſt over *Iſlip*, which is, by the ſame Admeaſurement, 57 ſuch Miles on that Road, and about five Miles almoſt due North from *Oxford*; ſo that the Center of the Shade left *Oxford* but very little upon the right Hand. This Situation agrees perfectly well with the former between *Barton* and *King's Walden*, and as far as the Geography of our Country may be depended on, I conclude the Center to have entred upon *England* about *Plymouth*, and to have paſt over *Exeter*, the *Devizes*, *Iſlip*, *Buckingham*, and *Huntington*, leaving *Oxford* and *Bedford* on the right, and *Lynn* on the Left, and to have quitted the Coaſt of *Norfolk* about *Wells* and *Blakeney*.

As

As to the Southern Limit or Term, where the Eclipſe ceaſed to be total on the South-ſide of the Sun, we have received an Account of an Obſervation made at *Norton-court*, about Ten Miles on this Side *Canterbury*, by the Reverend Dr. *Harris*, aſſiſted by that accurate Obſerver Mr. *Stephen Gray*, by which we learn that the Eclipſe began there at $8^h.\ 8'.\ 55''.$ and ended at $10^h.\ 24'.\ 47''$; and that the total Darkneſs continued but about one Minute or rather leſs, the middle thereof being at $9^h.\ 13'.\ 52''.$ From this Duration it will follow, that *Norton-court* was but about 3 or 4 Miles within the Shade. And that it was really ſo is confirmed by the Relation of the Inhabitants of *Bocton*, about Midway between *Norton-court* and *Canterbury*, who aſſured Mr. *Gray*, that the Eclipſe was not total there, but, as one of them expreſt it, before the Sun had quite loſt his Light on the Eaſt-ſide he recovered it on the Weſt: And that there was a ſmall Light left on the lower Part of the Sun that appeared like a Star. And from *Cranbrook* in *Kent*, we are informed, by the Relation of *William Tempeſt*, Eſq; that he obſerved there the Sun to be extinguiſhed but for a Moment, and inſtantly to emerge again: So that the Limit paſt exactly over this Town, which is about 38 Geographical Miles from *London*, and very near the right Angle, where the Perpendicular from *London* falls on the Line of the Limit, being $3'.\ 00''$ of time to the Eaſtward of *London*, in the Latitude of $51°.\ 6'$, as near as I can gather.

How it paſt over *Suſſex* we have no authentick Relations, but have learnt that it was total at *Wadhurſt* beyond *Tunbridge-wells*, as alſo for ſome ſhort time at *Lewis*; but that it was not ſo at *Brightling*, which Place being ſituated on an Eminence, all the Country to the Northward was ſeen in Darkneſs, whilſt they there had ſome Benefit of a ſmall Remainder of the Sun.

From theſe Obſervations we may conclude, that this Limit came upon the Coaſt of *England*, about the middle between *Newhaven* and *Brighthelmſton* in *Suſſex*, and paſſing by *Cranbrook* and *Bocton* about four Miles on the Right-hand, quitted the Coaſt of *Kent* not far from *Hern* toward the ancient *Regulbium*, now called *Reculver*. So that ſcarce one third Part of *Kent*, and not ſo much of *Suſſex*, out of all the South Coaſt of *Great-Britain*, eſcaped being involved in this Darkneſs.

The Northern Limit, having paſt over a much greater Space, has had more Obſervers, and is not leſs curiouſly determined than the other. By the Account given by the Reverend Mr. *Roger Proſſer*, Rector of *Haverford-Weſt*, the Eclipſe was total there a Minute and a half, whence it follows that *Haverford* was but about 6 Miles within the Shade, and therefore that it entred on *Pembrokeſhire* about the middle of St. *Bride*'s Bay, leaving St. *David*'s and *Cardigan* on the left Hand: and having traverſed thoſe two Counties and *Montgomery-ſhire*, it entred *Shropſhire*,

Shropſhire, leaving the Town of *Shrewſbury* 1′. 40″ in the Shadow, as was obſerved there by Dr. *Hollings:* whereby it appears that *Shrewſbury* was about 8 Miles within the Limit. Thence it proceeded by the Eaſt-ſide of *Cheſhire*, leaving *Whitchurch* and *Nantwich* a very little without, and paſſing by *Congleton* went over the *Peak* of *Derbyſhire* into *Yorkſhire*, and croſt the great Northern Road between *Pontefract* and *Doncaſter*, ſomewhat nearer the former than the latter. For by the Obſervations of *Theophilus Shelton*, Eſq; at *Darrington* about two Miles on this Side *Pontefract*, (in Lat. 53°. 40′ and Long. Weſt from *London* 4′. 40″. of time, as may be concluded from *Norwood*'s Meaſure of a Degree) the Sun at 9ʰ. 11′. was reduced almoſt to a Point, which both in Colour and Size reſembled the Planet *Mars*; but while he watched for the total Eclipſe, that Point grew bigger and the Darkneſs diminiſhed; whence he argued the Limit to have been very little more Southerly. And ſince has been informed, that it was juſt total in *Barnſdale*, three Miles South from thence. And that it was ſo at *Badsworth* about the ſame Diſtance from *Darrington*, we are told by a Letter of the Reverend Mr. *Daubuz*, that he has a certain Account from that Place, that the luminous Ring round the Moon was ſeen there, which was no where viſible but while the Eclipſe was total. From theſe *Data* we may ſecurely determine the Remainder of this Track, and that the Edge of the Shadow, having paſt over the reſt of *Yorkſhire*, paſſed off to Sea about *Flamborough* Head.

So that of the forty Counties, into which *England* is ſubdivided, only the five moſt Northerly have not had the Sun wholly hid from them; and ſix others have eſcaped but in Part, *viz. Shropſhire*, *Cheſhire* and *Yorkſhire*, and the extreme Part of *Darbyſhire* on the *North*, and *Kent* and *Suſſex* on the *South*; all the reſt of the Kingdom having more or leſs ſuffered an Interval of total Darkneſs.

I ſhall not at preſent conſider this Eclipſe as univerſal, but only as it related to *England*; and it ſhall ſuffice to ſay that the Shadow came out of the *Atlantick* Ocean, having paſt over the Iſlands *Azores*; and that the Southern Limit of it reach'd the Iſle of *Uſhant*, and the Northweſt Coaſts of *Britanny* between *Breſt* and *Morlaix*; and dividing our Iſlands of *Guernſey* and *Jerſey*, juſt touched upon the Promontory of *Normandy* called *Cape de Hague*. And that after it had quitted *England* and traverſed the *German Ocean*, it fell on *Jutland* on the Southſide, and *Norway* on the North; and thence proceeded to the Eaſtward over *Sweden*, *Finland*, &c.

It remains now to conſider the Figure, Poſition, Direction, Velocity and Magnitude of the Shadow as it paſſed over us. As to the Figure, 'tis obvious that the Shadow of the Moon being a Cone, and the Earth's Surface ſufficiently Spherical, the apparent Shadow on the Earth will be the common Interſection of a Cone and Sphere, which is a Figure hitherto little conſidered by Geometers; and not being *in Plano*, is not to

to be exactly deſcribed but in the ſpherical or conical Surface. How to find the Points of this Curve, in all Caſes, is ſhewn by *P. Couſier*, in a very ſcarce *Latin* Book printed at *Dijon* in *Burgundy*, and publiſhed at *Paris* in the Year 1663: Nor do I know of any other Author, that has handled the ſame Subject ſince, though capable and worthy of further Improvement. By what he there delivers, *Prop.* 11, 12. *Lib.* I. it will be eaſily underſtood, that the Convexity of ſo ſmall a Part of the Earth's Surface, as the Shadow commonly occupies, can produce only an inconſiderable Effect; ſo that without ſenſible Error we may take it for a Plane, and the Section for a true *Apollonian Ellipſis*, whoſe tranſverſe *Axis*, by reaſon of the Smallneſs of the Angle of the Cone, will be to its Conjugate nearly as *Radius* to the Sine of the Sun's Altitude at its Center, eſpecially if he be conſiderably elevated. But when he is near the Horizon, it will be neceſſary to have regard to the true Figure, by reaſon of the great Length, to which the tranſverſe Axe is extended, and particularly when the Shade is entring upon, or leaving the Earth's Diſk.

As to the Poſition of the *Axis* of the Shadow, it is manifeſt, that it muſt always lie in the Plane of a great Circle of the Earth, paſſing through the *Axis* of the Cone of the Shade; and therefore all that is required, is, to obtain the Azimuth and Altitude of the Sun, at the Place where the Centre of the Shade at any time is found, to determine the Situation of the Axe and *Species* of the Ellipſe required. Thus the middle of the Eclipſe at *London* having been obſerved at $9^h.$ $10'.$ $45''$, by the given Latitude and Declination, we find his Azimuth about $59°.$ $00'.$ and Altitude $40°.$ $46'.$ that is juſt 40 Degrees high at the Center of the Shadow. Wherefore the tranſverſe Axe of the Ellipſe was to its Conjugate very near as *Rad.* to the *Sine* of $40°$, or as 1000 to 643 *proximè*; and did make an Angle of $59°$, or very little more, with the Meridian paſſing at that time through the Center of the Shade.

The Direction and the Velocity of the Motion, wherewith the Center of the Shade paſt over *England*, is next to be conſidered, wherein it is to be obſerved, that the Shadow paſſes in a very compound Curve, which as the former is not *in plano*, and only deſcribable on the Surface of the Sphere: Nor is its Motion equable, but compounded of very many Elements, producing a great Variety. By what Method its Points, and its Tangents in thoſe Points, are to be obtained, I reſerve to another Opportunity; only I obſerve, that for ſo ſmall a Part of the Curve, as went over *England*, it may be eſteemed a right Line, with more Exactneſs, than we uſually find in moſt of our Geographical Charts. And the ſame may be ſaid for the Velocity, which, though in our preſent Inſtance, it was continually decreaſing, may, for ſo ſhort a time, be ſuppoſed to have been the ſame without ſenſible Error.

By a careful Calculation, I have determined the Velocity of the Motion, at the time of the middle of the Eclipſe at *London*, to have been 29 Geographical Miles in a Minute of time *quam proximè:* And that its way made an Angle of 52°. 45′. with the Meridian towards the Eaſtwards of the North; wherefore the ſaid way made an Angle with the Axis of the Ellipſis of 68°. 15′. And the greateſt Duration of total Darkneſs having been 3′. 57″, it will follow, that that Diameter of the Elliptick Figure according to which the Shade paſt, was no leſs than 114$\frac{1}{2}$ Geogr. Miles. And from the Elements of the Conicks 'tis eaſy to be proved, that ſuppoſing the Figure of the Shade a true Ellipſe, whoſe Axes are as *Radius* to the *Sine* of 40 Degrees, the greater Axis would be 171 Geographical Miles, and the leſſer 110; and the neareſt Diſtance between the Limits ſuppoſed Parallel 164 ſuch Miles.

And this Length of the *Axis* of the Shade, derived purely from the Duration of total Darkneſs, is fully confirmed by the obſerved Diſtance of the Parallel Limits; the one paſſing by *Badſworth* in *Yorkſhire*, the other by *Cranbrook* in *Kent*. For by the two Latitudes 53°. 37′ and 51°. 6′, with the Difference of Longitude 7′. 40″. of time, or 1°. 55′, the Diſtance of theſe two Places is given 166$\frac{1}{2}$ Geogr. Miles; with the mean Angle of Poſition 25 Degrees from the North Weſtwards; wherefore this Arch makes an Angle with the Track of the Shade of 77° $\frac{1}{4}$, and hence the neareſt Diſtance of the Parallels becomes 163 ſuch Miles, which by the other way was found 164.

If then we conclude the *Axis* of the Shadow, when the Sun was juſt 40 Degrees high, to have extended over 2°. 50′ of a great Circle, we may ſecurely determine the Difference of the Sun and Moon's Diameters at this time. For the Difference of the Horizontal Parallaxes of the Sun and Moon being found to be 60′. 38″. (as ſhall be hereafter ſhewn, but is not required with extreme exactneſs for this Purpoſe) the Difference of the Parallaxes in Altitude at both Ends of the Axis, will be found to be 1′. 56″, and by ſo much did the Diameter of the Moon, when forty Degrees high, exceed that of the Sun: Hence the Horizontal Diameter of the Moon, in this Anomaly is found 33′. 27″, which may ſerve for a Rule in all other Caſes.

I forbear to mention the *Chill* and *Damp*, with which the Darkneſs of this Eclipſe was attended, of which moſt Spectators were ſenſible, and equally Judges; or the Concern that appear'd in all Sorts of Animals, *Birds*, *Beaſts* and *Fiſhes* upon the Extinction of the Sun, ſince ourſelves could not behold it without ſome Senſe of Horror.

Laſtly, I have added the following *Synopſis* of ſuch Obſervations as have hitherto come to my Hands.

Place	Obſervers	Beginn. h. ′ ″	Immerſ. h. ′ ″	Emerſ. h. ′ ″	Tot. ′ ″	End. h. ′ ″
Barton	M. *Bridges*				3. 53	
Bell-bar	M. *Jones*	8. 6. 25	9. 9. 45	9. 13. 27	3. 42	
Broadway } *Carmarth.* }			8. 47. 00	8. 49. 30	2. 30	10. 21. 57
Cambridge	M. *Cotes*			9. 14. 37		10. 24. 30
Canterbury	M. *Gray*	8. 10. 00				
Cheſter	M. *Ward*	7. 57. 40				10. 6. 35
Crew	M. *Wright*		9. 2. 8		2. 00	10. 9. 00
Dublin	*L. Archbiſh.*	7. 42. 11				9. 49. 40
Dublin	M. *Hawkins*	7. 41. 30				9. 48. 45
Exon	*L. Biſhop*		8. 55. 0	8. 59. 0	4. 00	10. 0. 00
Exon	M. *Hudſon*	7. 47. 30			3. 30	10. 0. 30
Greenwich	*M. Flamſteed*				3. 11	
King's Wald.	M. *Whitſide*				3. 52	
Llanidan } *Angleſey* }	M. *Rowland*	7. 52. 30				
London	*R. Society*	8. 6. 00	9. 9. 3	9. 12. 26	3. 23	10. 20. 00
Northampt.	M. *Hawkins*		9. 5. 22	9. 9. 24	4. 2	10. 15. 35
Norton-court	D. *Harris*	8. 8. 55	9. 13. 23	9. 14. 22	0. 59	10. 24. 47
Oxon	D. *Keill*				3. 30	10. 15. 10
Paris	*R. Academy*	8. 11. 00				10. 28. 00
Plymouth	M. *Heines*	7. 41. 00	8. 45. 30	8. 50. 00	4. 30	9. 54. 30
Portcheſter	C. *Chandler*		9. 2. 25	9. 6. 15	3. 50	
Salop	D. *Hollings*	7. 58. 00			1. 40	10. 6. 00
Upminſter	M. *Derham*	8. 7. 41	9. 10. 58	9. 14. 6	3. 8	10. 21. 45
Wanſted	M. *Pound*	8. 6. 37	9. 9. 28	9. 12. 48	3. 20	10. 20. 32
Weymouth	M. *Hobbs*		8. 53. 00	8. 58. 00	4. 00	
Witley	M. *Baxter*	7. 59. 0			3. 15	10. 13. 00

Accounts of the ſame *from* abroad, n. 345. p. 314. — *near the Iſland* Forte ventura, *by Mr.* J. Edens.

2. Since the Publication of the former Account of what was obſerved in *England*, and particularly at *London*, of this Eclipſe, we have received from foreign Parts the following Obſervations.

Mr. *J. Edens*, being on his Voyage to the Pike of *Teneriff*, obſerved the Eclipſe at Sea, in Latitude by Obſervation 34°, 20′, and Longitude 0^h 54′, Weſt from *London*, as he concluded by their Diſtance and Poſition from the Iſland *Forte ventura*, which they ſoon after fell in with. He writes that it began at VI^h. 49′, and ended at $VIII^h$. 47′. this latter very exactly, though not quite ſo nice as to the Beginning.

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Had this Gentleman ſignified, what Difference of Meridians there was found between the Place of Obſervation, and the Weſt End of *Forte ventura*, we might, without ſenſible Error, have concluded the true Longitude, not only of that Iſland, but alſo of the Pike of *Teneriff*, where *Our Geographers* and the *Dutch* have fixed their firſt Meridian. He adds, that the greateſt Darkneſs was about $\frac{1}{4}$ of the Sun's Diameter, or nine Digits on the North Side.

From *Germany* we have received the following Accounts.

At *Nurenburg*, The Beginning and greateſt Obſcurity could not be ſeen for Clouds, but the End happen'd at $x1^h.\ 10'.\ \frac{1}{2}$. — *at* Nurenburgh.

At *Hamburg*, The Beginning was obſerved at $VIII^h\ 57'$. the greateſt Obſcurity at $x^h.\ 5'.\ 30''$, when $x1\frac{1}{2}$ *digg.* were darkned. The End could not be obſerved for Clouds. — *at* Hamburgh.

At *Keil* in *Holſtein*, The Beginning $1x^h.\ 14'$. The greateſt Obſcurity $x^h.\ 19'.\ 20''$, and the Quantity then eclipſed x1 *digg.* 20′. The End was at $x1^h.\ 29'$. — *at* Kiel in Holſtein.

At *Berlin*, The Beginning could not be obſerved for Clouds, but the greateſt Obſcurity was at 22 *min.* paſt Ten, when x1 *digg.* were eclipſed. The juſt End was at $x1^h.\ 34'$. — *at* Berlin.

At *Franckfort* on the *Meine*, The Eclipſe began at $VIII^h.\ 50'$. The greateſt Darkneſs at $x^h.\ 11'$, *but perhaps ſhould be* $x^h.\ 01$ *min.* the Digits being x. and 34 *min.* The End was obſerved at 10 *min.* paſt Eleven. — *at* Franckfort *on the* Meine.

By whom theſe Obſervations were made, and with what Inſtruments, we are not as yet informed, but hope they may be exact enough to confirm the *Longitudes* of thoſe ſeveral Places, which are at preſent reaſonably well known.

In a Book entituled, *Nouvelles Literaires*, publiſh'd at the *Hague*, *pag.* 404, 405. there is an Account of the Obſervation of this Eclipſe at *Upſal* in *Sweden*, made by M. *Jo. Waller*, Profeſſor of Mathematicks in that Univerſity, who was very careful to obſerve it exactly; the times being verified by three Clocks perfectly agreeing with one another and with the Sun: But more eſpecially by a Quadrant of 5 Foot Radius for taking the Sun's Altitude. By this Inſtrument, he determined the Height of the Pole at *Upſal* 59°. 51′. 54″. And by the ſame, a little before the beginning of the Eclipſe, he found the Height of the Sun 39°. 36′. 42″. his Clocks then ſhewing the Hour $1x^h.\ 47'.\ 50''$, which proves that they were very near the true time. At $x^h.\ 58'.\ 15''$. the Altitude of the Sun being 44°. 17′. 29″, was the Beginning of the total Darkneſs, and at $x1^h.\ 2'.\ 24''$. was the End thereof, *alto ſole* 44°. 29′. 13″. ſo that here the Duration of the total Eclipſe was 4′. 9″, and the Middle thereof but one third of a Minute after Eleven. And laſtly, the End is ſaid to have happen'd about 4 Minutes before Noon, the Sun being 45°. 42′. 6″. high: But in this is a manifeſt Error, for it makes the time of Emerſion, or from the Middle to the End, but 55′. 20″; whereas being ſo near the Meridian, 'tis certain that this Emerſion was the greater Part of the Duration of — *at* Upſal *in* Sweden, *by Mr.* J. Waller.

the whole Eclipſe, and conſequently more than an Hour. Perhaps the times might be deduced from the Altitudes only, and then the Miſtake might be in ſuppoſing the End ſo much before Noon, as it was really after it. However, to prevent all Doubts, we have compared this Obſervation, with what we obſerved of this Eclipſe at *London*, and find that in the Latitude of 59°. 50′, the Place where the middle of total Darkneſs was at $x1^h.$ 0′. 20″, was near 19 Degrees more Eaſterly than *London*, (that is exactly in the Meridian of *Dantzick*) and that the Eclipſe began there at $x1^h.$ 52′½, and ended at $x11^h.$ 10″, wherefore the Duration could not be $2^h.$ 7′. 50″, as the *Editor* of the ſaid *Nouvelles* has publiſhed; not conſidering, that the Beginning could not be ſeen for Clouds, as in the very next Words he aſſures us.

As to the Darkneſs, it was ſuch, that they could ſcarce diſtinguiſh one another; and beſides *Jupiter*, *Mercury* and *Venus*, of the fix'd Stars, *Caſſiopea*, *Capella*, *Oculus Tauri* and *Orion*, (*Sirius not being yet riſen*) were viſible.

Eclipſe of the Sun, Feb. 19. 1718. O. S. *at* Norimberg, *by Mr.* Wurtzelbau, *and at* Berlin, *by Mr.* G. Kirch, n. 357. p. 822.

XVI. Obtinuimus è *Novis Literariis Berolinenſibus* duplicem obſervationem *Eclipſeos* exiguæ *Solaris*, *Feb.* 19. *St. Vet.* 1718; alteram *Noribergæ* a Cl. D. *Wurtzelbau*, alteram a D. *Kerchio Berolini* habitam.

Noribergæ Sol ortus eſt aliquantulum deficiens in Limbo ſuperiore, qui quidem defectus ad tres plenè digitos accrevit; Deſiit Eclipſis $8^h.$ 8′. 48″. circa 60 grad. à vertice ſolis ad ſiniſtras. *Berolini* vero Sol ſtatim ab ortu cæpit deficere, Horâ *Scil.* $6^h.$ 49′. vel 49′½. Circa medium Eclipſeos, nempe $7^h.$ 35′, erant partes lucidæ in ſole reſiduæ 24′. 40″, unde digiti obſcurati $2^{dig.}$ 50′. Finis autem incidit in $8^h.$ 28′. 10″.

Eclipſe of the Moon *at* Cambridge *in* New-England, *Feb.* 11. 1700. *by Mr.* T. Brattle, n. 202. p. 1633.

XVII. On *Feb.* 11^{th} the Moon roſe eclipſed, and the Horizon was ſo overcaſt, that I deſpair'd of having any Obſervations; but at ½ an Hour paſt 6. ſhe came from under the Cloud, and at $6^h.$ 25′. I had juſt a Sight of her, and judged her eclips'd about 5 digits; at

h		
6	29	The Section equidiſtant from M. Ætna, and Horminius.
	32	Palus Maræotis begins to be ſeen.
	34½	Palus Maræotis, and Mons Apollonius ½ out.
	37½	Palus Maræotis quite free, and Palus Maræotis, and Palus Mæotis in the Perpendicular.
	42½	The Shadow near an Inch from Palus Maræotis, Mons Horminius, and Mons Hercules.
	46¼	Palus Maræotis in the Nadir, and that Part of Palus Mæotis to my Right-hand in the Prime Vertical.
	57	The upper Part of the Section is now, and has been for a long time in Inſula Major in Mare Caſpio (and the Section now perpendicular) and the lower Part wheeling about from Palus Maræotis.

h	′	
7	20	Mount Sinai firſt appears at 22′ wholly free.
	25½	Palus Maræotis, and Mons Horminius near perpendicular.
	43	The Eclipſe over in the Teleſcope, and at 49 to the naked Eye.

My Clock was ſet by my Ring-Dial about 9 of the Clock in the Morning, as exactly as I could judge; and the Obſervation was made with my 4½ Foot Teleſcope, with all four Glaſſes in it.

Eclipſe of the Moon, Dec. 12. 1703. *at* Cambridge *in* New England, *by Mr.* T. Brattle, n. 292. p. 1656.

XVIII. 1.]
Time by the Clock.

h	′	
11	45	In the Morning, that Part of the Moon's Diſk near Alabaſtrinus, look'd ſomewhat duſkiſh, and the Eclipſe beginning to enter between Palus Maræotis and M. Porphyritis.
11	53	The true Shadow was well entred.
	58	M. Porphyritis juſt cover'd.
12	03½	near 3 Digits darkened.
	7½	Mount Ætna begins.
	9½	quite covered.
	14½	Lacus Niger major and M. Sinai almoſt equidiſtant from the Section of the Shadow, Lacus Niger Major, being ſomewhat the nearer of the two.
	18¼	Lacus Niger Major begins, 19½ quite covered.
	21¼	Mount Sinai begins.
	21¼	Quite covered and the Moon about 6 digits eclipſed.
12	24½	Beſbicus begins.
	26	Quite covered.
	28¼	Byſantium begins.
	29½	Covered and Mount Horminius begins.
	32	Apollonia begins.
	33	Covered.
	37	The Shadow equidiſtant from M. Corax and Mount Paropamiſus, or ſomewhat nearer to M. Corax.
	39½	Between 9 and 10 Digits eclipſed.
	43	M. Corax begins.
12	44¾	Palus Mæotis begins, and at 45¼ the inner of M. Paropamiſus begins.
	50	Palus Mæotis quite covered.
	51½	The Moon not quite eclipſed.
	52	Nor yet.
	53	Nor yet.
	54	Scarce.
	54½	Quite immerg'd and the Mora begins.
14	39	Preciſely, ſhe emerg'd between Palus Maræotis and Mons Porphyritis.

h	′	
	42	Palus Maræotis begins.
	43	Quite clear.
	47	M. Porphyritis quite clear.
	55	About 3 Digits reſtor'd.
	59	Mount Ætna begins.
15	02	That and Lacus Niger Major at the ſame time clear.
	8 ½	Mount Sinai about half free.
	9 ½	Quite free, and about 6 digits reſtored.
	15	Beſbicus free.
	19¼	Byſantium free.
	29½	About 9 Digits ſeem'd to be reſtor'd.
	30¼	Mons Herculis free.
	32¾	Palus Mæotis begins.
	38½	Quite free.
	41½	Inſula Major in Mare Caſpio free, and in the middle of the Section.
	42½	Not yet wholly clear.
	45	Fully over in the Teleſcope, tho' a kind of a Smoak remained ſome little after to the naked Eye.

In order to the adjuſting of the time, I ſet my Clock with the greateſt Exactneſs I could the Morning preceding, both from my Ring-Dial and the riſing of the Sun, which I very narrowly watch'd and obſerved, and found it to agree with the Sun's ſetting the following Evening; ſo that it went all the time the Eclipſe was, very ſteadily and regularly; but for the greater Certainty and Satisfaction, I took the Altitudes of the following Stars with the Braſs Quadrant with Teleſcope Sights out of my Chamber Window, the lowneſs whereof would not permit me to take them, when they were at all higher elevated.

* in dextro humero Orionis.

By the Watch h	′	Comp. Alt.		h	′	″	Differ. ′	″	
6	15	78	18	6	13	40	1	20	*So that my Clock went by theſe Obſervations neareſt 1′ too faſt.*
6	21½	77	03	6	20	28	1	02	
	26¼	76	11	6	25	08	1	07	
Procyon									
8	9¼	77	20	8	08	04	1	11	
	14½	76	20	8	13	32	0	58	
	21	75	13	8	19	36	1	24	
Re- 10	8½	77	46	10	07	18	1	12	
gulus	17¼	76	11	10	15	58	1	17	

2.] I had the good Fortune at *London* near the *Exchange* to make ſome few Obſervations of the Eclipſe of the *Moon* of *December* the 11th, 1703. (of which I gave an Account to the Society ſome Time ſince) as follows:

— *the* ſame *obſerv'd at* London, *by Mr.* J. Hodgſon. n. 291. p. 1594, n. 292. p. 1637.

The Heavens being cloudy moſt Part of the Night, it was 35′ after Four in the Morning following, before I could perceive that the Moon was eclipſed; and then as near I could judge, ſhe had been ſo about three or four Minutes at moſt, from whence we may conclude it began at *London* about 31 or 32 Minutes after Four the ſame Morning.

Mr. *Brattle* found, that at 44 Minutes after Eleven at Night, Part of the Moon's Disk look'd ſomewhat duskiſh, and that at 52 Minutes, the Shadow was well enter'd, *ſo that from hence, as well as from a Compariſon of the Ingreſs and Egreſs of the principal Spots, it probably began there about* 49 *Minutes after Eleven, whence it follows, that* Cambridge *in* New-England *lies* $4^h\ 42'\ \frac{1}{2}$, *or* 70 37′ *to the Weſtward of the Meridian of* London.

Difference of Longitude *between* London *and* Cambridge *in* New-England.

I happen'd to ſee the Moon the ſame Morning at 35 Minutes after Five, when ſhe wanted at moſt but three Minutes of being totally eclipſed; ſo that at *London* ſhe immerged at 38 Minutes paſt Five.

Mr. *Brattle* ſaw her immerge exactly at 54 Minutes after Twelve, whence it follows, that the Difference of the Meridians found by comparing theſe Obſervations, is $4^h\ 43'\ \frac{1}{2}$, or 70° 52′, agreeing very well with the former; ſo that by taking a Mean between them, the Difference of Longitude of the two Places $4^h\ 43'$, or 70° 45′.

I ſaw no more of the Eclipſe that Morning, by reaſon of the Clouds, and ſhould be very glad to meet with ſome other Obſervations to confirm theſe; but their mutual Agreement gives great Reaſon to believe that the Deductions are good, and may be rely'd upon; for during the Eclipſe I had a View of the Moon at leaſt twenty Times, tho' Clouds frequently intervening have made this Account of mine leſs accurate and certain than otherwiſe it would have been.

XIX. *Immerſiones.*

	Tempus ex Alt. correct. H.	′	″
Penumbra valdè notabilis, (*Veſpere*)	6	52	
Palus Maræotis tegitur	6	58	20
M. Porphyrites incipit	7	8	15
Tegitur	7	9	20
M. Ætna incipit	7	16	
Penitùs tectus	7	17	15
M. Sinai incipit	7	21	40
Planè tectus	7	22	40
Inſula Corſica tegitur	7	24	
Lacus niger major tegitur	7	31	40
Inſula Besbicus	7	33	

Eclipſe of the Moon, Apr. 5 1707, *at* Boſton *in* New-England, *by Mr.* T. Brattle. n. 312. p. 2471.

			H.	′	″
Immerſiones.					
Bixantium			7	36	30
M. Horminius			7	37	20
M. Apollonii			7	40	30
M. Hercules			7	44	30
M. Corax			7	51	30
Palus Mæotis incipit			7	52	45
Inſul. Maj. in M. Caſpio incipit			7	54	45
Tegitur			7	56	
Palus Mæotis omnino tegitur			7	57	30
Luna plena Immerſa			8	1	15
Emerſiones.					
Comp. Alt. Arcturi	53°	34′	8	28	
	51	30½	8	39	15
Comp. Alt. ſtellæ quæ ſequitur lucidum in corona ſeptentrionali					
Lat. 44° 33′	60°	2′	9	0	30
	56	57	9	17	15
Luna Emergere planè incipit			9	46	30
M. Ætna tota illuſtrata			10	9	30
M. Sinai tota apparet			10	10	15
Inſula Beſbicus			10	25	
Bizantium			10	28	30
M. Apollonii			10	33	
M. Hercules			10	36	30
Palus Mæotis incipit			10	44	
Inſula Major in M. Caſpio reſtauratur			10	47	
Palus Mæotis tota retecta			10	49	
Luna plenè illuminatur			10	54	

Eclipſe of the Moon April 1J. 1707. *at* Zurich *by the two Doctors,* Scheuchzer's n. 310. p. 2394.

XX.

H.	Min.	S.	
12	9ad	18	Penumbra ex parte Maræotidis.
	18	40	Umbra vera intra diſcum.
	20	15	Palus Maræotis in Umbra.
	23		Maris Eoi principium.
	25	20	Mons Alabaſtrinus. Medium Maris Eoi.
	27	40	Principium ſinus Sirbonii.
	29		Medium ſinus Sirbonii, & Mare Ægyptiacum.
	29	20	Principium inſulæ Cercinnæ.
	29	30	Lacus Meridionalis.
	30	30	Medium Cercinnæ.
	31	40	Finis Cercinnæ.
	33		Extrema protenſio Montis Sopher.
	34		Inſulæ inter Siciliam & Cercinnam.
	35		Principium Mauritaniæ, & ſinus Hyperborei.
	36	40	Medius ſinus Hyperboreus.

H.	Min.	S.	
	37	20	Mare Pamphilium.
	37	30	Creta.
	37	40	Principium Ætnæ.
	38	40	Medium Ætnæ. Melos. Carpathos.
	39	30	Finis Ætnæ.
	41		Rhodus.
	43	40	Initium Sinai.
	45		Medium Maris Adriatici, & Sinai.
	45	20	Sinai Finis.
	46	30	Medium Adriatici.
	48	40	Principium Propont. & Maris Hyperborei.
	51	30	Medium Propontidis, & finis Adriatici.
	52	40	Principium Lacus nigri majoris.
12	53	10	Lacus Thraſumenus.
	53	30	Medium Lacus nigri minoris.
	54	30	Principium Inſulæ Beſbyci.
	55	10	Principium Ponti Euxini in ſinu Salmydeſſo.
	56		Finis Propontidis.
	57	30	Ponti Euxini inferioris principium.
	58		Byzantii principium.
	59	10	——— Finis.
	59	40	Promontorium Acheruſium.
1	1		Boryſthenis principium. Apollonia.
	1	30	Medium Ponti Euxini.
	3	20	Sinus Athenienſis Medius.
	4	40	Palus Byces.
	5	40	Promontorium Heracleum.
	7	40	Cochilis media. Finis ſinus extremi Ponti.
	8	30	Lacus Corocondæ Medium.
	9	20	Promont. Hercul. & Maris Caſpii initium.
	11	40	Initium Paludis Amadocæ.
	16	20	——— Medium.
	18	10	——— Finis.
	20		Paludes amaræ, & Lacus minor.
	20	40	Lacus major.
	22	10	Tenuiſſimus margo lucidus.
	23	20	Lunæ corpus totum in umbra.
	24	40	Diſcus Lunæ integer ferè, excepto Mari Mediter. diluto quodam fulgore ſplendet, ut Maria diſtingui poſſint per Tubum.
	40		Alia macula præter paludem Mæotidem per Tubum diſtingui nequit.
	45		Lunæ Diſcus medius magis magiſque obſcuratur, ambitu manente lucidiore.

H.	Min.	S.	
2	12		Diſcus Lunæ Rutilo colore nudo oculo refulgebat, nec per Teleſcopium macula ulla diſtingui potuit.
	15		Totus Diſcus obſcurior magis, & magis, Peripheriâ manente lucidiuſculâ,
	28		Splendidior Diſcus è regione Paludis Maræotidis, umbraque denſiſſima verſus Paludem Mæotidem.
	33		Senſim lucidior reddit. integer Diſcus, obſcurit. majore tegente Paludem Mæotid. ejuſque loca vicina.
	51	40	Redeunt ſenſim veſtigia Marium.
	56	30	Pontus Euxinus, & Mare Caſpium, in mediâ obſcuratione manent veluti nebulâ craſſa perfuſa.
3	5		Diſtingui poteſt Mare Eoum, & vicina, ut ut Luna nondum ex umbra emerſerit.
	9	40	Emerſionis initium verum.
	11	30	Incipit emergere Palus Maræotis.
	13		Evaſit.
	15	40	Incipit Mare Eoum.
	21	30	Evaſit ſinus Sirbonius, & Mare Ægyptium.
	26		Evaſit Caſſiotis Regio, & aliquot minuta ante Cercinna inſula.
	27	40	Evaſit Athos Mons, & Maltha.
	31		Emerſit Mauritania.
	38		—— Corſica, & Sicilia.
	44		—— Mare Adriaticum.
	45	20	—— Media Propontis.
	49		—— Beſbycus.
	52		—— Byzantium.
	57	30	—— Promontorium Acheruſium.
4	5	20	Emerſit Pontus Euxinus, & medium Caſpium.
	6		Incipit Mæotis Palus.
	2		Emerſit Caſpium, & Media Mæotis.
	11	20	Emerſit Mæotis.
	13	40	Penumbra.
	14	20	Luna tota integra.

In Emerſione videbatur mihi umbra diſtinctior, quam in immerſione.

12	18	40	Eclipſeos initium in umbra vera.
1	23	20	Obſcuratio maxima.
3	9	40	Emerſionis initium.
1	46	30	Duratio totalis obſcurationis.
4	14	20	Emerſionis finis.
3	55	50	Tota Duratio.
1	5	40	Ab initio ad Immerſionem Lunæ totalem.
1	5	40	Ab emerſione totalis Eclipſeos ad finem.

XXI. As I was coming from *London*, *Sept.* 18. in the Evening, I obſerved for half an Hour or more a thin Shade to poſſeſs that Part of the Diſk where the Eclipſe began, which remain'd a good while after the Eclipſe was over. After I got Home, I got all things in Readineſs before the Eclipſe began. The principal Obſervations were as follow:

Eclipſe of the Moon, *Sept.* 18. 1708. *at* Upminſter, *by Mr.* W. Derham, n. 320. p. 312.

The App. Time	Corr.	
h	′	″
7	56	30
7	57	40
7	59	00
8	00	00
9	01	00
9	16	40
10	23	11
10	25	00
10	26	00
10	28	15

A thin Penumbra.
A darker Penumbra.
Yet darker, which may paſs for the Beginning of the Eclipſe.
The Eclipſe no doubt begun.
The Lucid Parts of the Moon, not long before the middle of the Eclipſe, were 925 Parts of my Micrometer.
Diameter of the Moon 1634 Parts of the Micrometer.
The End of the Eclipſe draws nigh.
A little Obſcuration.
Leſs.
A very little, excepting the Duſkiſhneſs before mentioned.

XXII. In the laſt *Lunar* Eclipſe on *Feb.* 2. 1709-10, the time of the End (which was what alone the want of a proper *Apparatus*, and a favourable Sky would give me leave exactly to determine) I found to be the ſame (with but a very inconſiderable Difference) which the *Calculation*, according to Sir *Iſaac Newton*'s admirable Theory, promiſed me to expect.

I have added the Calculation from Mr. *Flamſtead*'s Tables according to Mr. *Horrox*'s Theory, as I find them publiſh'd in Mr. *Whiſton*'s Aſtronomical Lectures, with the *Radix's* or the mean Motions, corrected according to their firſt Authors later Obſervations, which are the ſame with thoſe aſſumed in Sir *Iſaac Newton*'s Theory.

By comparing theſe two Calculations, we may obſerve, that tho' moſt of the additional Equations in Sir *Iſaac Newton*'s Theory be very ſmall in this Situation of the Moon, yet they all conſpire ſo as to make its Place conſiderably more agreeable to Obſervation, than thoſe of *Horrox*'s Syſtem.

The Obſervation was made at *Streatham*, about ſix Miles near direct South of *London*, with a very good eight Foot Teleſcope. To correct the Clock, (for want of an Inſtrument) I carried with me next Day two Watches, that were before adjuſted to the Clock, and compar'd them with Mr. *Flamſtead*'s at the Royal Obſervatory, having firſt noted its Error by an Obſervation of the Sun's Tranſit of the Meridian his Aſſiſtant communicated to me: Upon my Return, I found my Watches ſtill to agree together, and to my Clock, which proved them to have gone true, and gave me the exact Error of my Clock, and the true Time at Obſervation.

The Account of the Moon's *Eclipſe*, Feb. 2. 1709-10. Compared *with the* Calculation, *by Mr.* H. Creſſener, n. 325. p. 16.

Mr. *Flamſtead* has ſince been pleaſed to acquaint me, that by his Obſervation of the meridional Tranſit of the *Lyon's Heart* during the Eclipſe, his Clock needed a yet farther Correction of one Minute, which I have here accounted for.

	17$\frac{0}{10}$. *Feb.*	*D.*	*H.*	*M.*	*Sec.*
The mean Time of the mean Oppoſition		2	4	9	42
The mean Time of the true Oppoſition		2	10	54	48
At which the true Place of the Sun is		10	24	55	50
And its Æquation to be added.					

The Place of the Moon from Sir Iſaac Newton's *Theory.*

	S.	*D.*	′	″
Mean Motion of the Moon	4	26	57	37
Annual Æquation Subtr.			8	34
The correct mean Motion	4	26	49	03
Mean Motion of Apog.	11	18	13	54
Annual Æquation of Apog. Ad.			14	31
Correct mean Motion of Apog.	11	18	28	25
Second Æq. from the Diſt. of Ap. from Sun Ad.			2	57
Place of the Moon the 2^{d} Time Æquat.	4	26	52	00
Mean Motion of Node	11	01	34	25
Æquation of Node Subt.			06	54
Correct mean Motion of Node	11	01	27	31
The 3^{d} Æquat. of the Moon from Node's Aſpect with the Sun Subt.				10
Place of the Moon the 3^{d} Time Æquated	4	26	51	50
Second Æquation of Apog. Subtr.		7	45	41
True Place of Apog.	11	10	42	44
Mean Anomaly	05	16	09	06
Æquation of Center Sub.		1	53	31
Moon's Place the 4th Time Æquated	4	24	58	19
The Variation. Ad.				11
Moon's Place the 5th Time Æquated	4	24	58	30
The 6th Æquation from the Diſtance of Luminaries and Apog. Ad.			1	20
Moon's Place 6th Time Æquated	4	24	59	50
The 7th Æquation. Ad.				34
True Place of the Moon in its Orbit.	4	25	00	24
True Place of the Sun	10	24	55	50
Moon beyond the Oppoſition			4	34
Which divided by the Horary Motion of Moon from Sun, gives		*D.*	*H.*	7	42
The mean Time therefore of Oppoſit.	*Feb.*	2	10	47	06
And the true Time		2	10	32	20

Mean

Mean Motion of the Moon	4	26	57	37	*The Place of the Moon according to Mr.* Horrox's *Theory.*
Phyſical Parts Sub.			8	21	
Correct mean Motion	4	26	49	16	
Mean Motion of Apog.	11	18	13	54	
Æquation of Apog. Sub.		7	25	00	
Mean Anomaly	5	16	00	22	
Æquation of the Center Sub.		1	53	53	
Place of Moon in its Orbit	4	24	55	23	
Diſtance from the Oppoſition				27	
That is in time to be added				45½	
The mean time therefore of true Oppoſition is exactly	D. 2	H. 10	55	33	
The apparent time	2	10	40	41	
Place of Moon in Ecliptick	4	24	57	27	
Reduction between the true Oppoſition and middle of Eclipſe. Ad.	D.	H.	2	47	
Middle of Eclipſe	2	10	43	34	
Continuance of Eclipſe		2	55	06	
Digits Eclipſed		9	55		
Beginning of Eclipſe	2	9	16	01	
End of Eclipſe		12	11	07	
End of Eclipſe by the Moon's Place from Sir *Iſaac Newton*'s Theory.		12	02	00	
End by Obſervation		12	01	30	
End by Calculation from *Horrox*'s Theory		12	11	08	

The Error therefore of Sir *Iſaac Newton*'s Theory is by this Obſervation but half a Minute, or none; of *Horrox*'s Syſtem, nine Minutes and a half.

XXIII. The Evening being clear, gave me a good Opportunity of obſerving the Lunar Eclipſe. The Times are very nice, and the Obſervations made with an excellent Six-foot Teleſcope, as followeth. *Eclipſe of the Moon*, Jan. 12. 1711-12. *at* Upminſter *by Mr.* W. Derham, n. 336. p. 52.

h	′	
6	15	A Duſkiſhneſs upon the N. Eaſt-ſide of the Moon.
6	36	A thick *Penumbra* on the Moon.
6	37	The *Penumbra* ſo denſe, that it may be taken for the Beginning of the Eclipſe.
6	39	The Eclipſe undoubtedly is begun.
6	41	The Shadow ſo dark, that it nearly hid the Moon's N. Eaſterly Limb.

h.	′	
7	21	Moon's Diameter by the Micrometer 1612 equal Parts, equal to 31′ 25″.
7	25	The Diſtance of the Shadow from the oppoſite luminous Limb of the Moon, repreſented by the Line *l. u.* was 1025 Parts of the Micrometer, equal to 20 Minutes.
8	31	End of the Eclipſe is very near.
8	32	End of the Eclipſe.
8	32	45″ Eclipſe is undoubtedly ended.
8	36	A *Penumbra* is left.

It unluckily fell out, that I diſordered my Micrometer at the Beginning of the Eclipſe; ſo that I could not take with any exactneſs the Inclination of the Cuſps, and ſome other Matters I had a Mind to have obſerved; to ſupply which Defect in ſome meaſure, I have ſent a *Type* of the Eclipſe, as well as I could, by gueſs. And from the ſame Defect I cannot warrant the Micrometrical Meaſures of the Moon's Diameter, and her eclipſed Parts to be otherwiſe, than ſomewhat near the Truth; perhaps not exactly true.

Fig. 120. A *Type* of the Lunar Eclipſe *Jan.* 12. 1711-12.

m. i. c. r. repreſents the two Claſpers of the Micrometer, parallel to the Equator.

N. The Northern, *S.* the Southern Part of the Moon's Diſk, running between the Claſpers of the Micrometer.

l. u. The enlightned Part of the Moon, being 1025 Micrometrical Parts, or 20′.

I am ſorry I had not *Hevelius*'s Map of the Moon, to have noted the Spots the Shadow paſſed over.

XXIV. *Eclipſe of the Moon*, Oct. 30. 1715. *at* Wanſted, *by Mr.* J. Pound.

Obſ.	App. Time. h	′	″		′	″
1	15	09	00	The Eclipſe had been for ſome time begun		
2		17	00	The Moon's Diameter meaſured by a Micrometer was	34	04
3		22	25	The Chord connecting the Horns	30	28
4		35	45	The inlightned Part of the Diameter continued to the Chord between the Horns	19	58
5		43	24	The inlightned Part of the Diameter	13	52
6		49	50	The ſame repeated	12	02
7		52	43	The ſame repeated	11	44
8		56	51	The inlightned Part of the Diameter continued to the Chord between the Horns	15	22
9		59	27	The inlightned Part of the Diameter	10	35
10	16	04	04	The ſame repeated	9	43

	h.	′	″		′	″
11		18	34	The ſame again repeated	09	07
12		23	45	The Chord between the Horns	32	35
13		26	30	The ſame repeated	33	07
14	16	31	16	The ſame again	33	19
				At which time alſo the Shade paſſed thro' the middle of *Schikardus*.		
15		37	15	The Chord between the Horns, agreeing with the ☽'s Diameter	33	57
16		40	45	The inlightned Part of the Diameter	11	56
17		43	40	The ſame produced to the Chord between the Horns	16	13
18		46	55	The ſame repeated	17	28
19		47	57	The inlightned Part of the Diameter	13	38
20		52	57	The ſame	15	30
21		55	27	The Edge of the Shadow paſſed through the Middle of *Gaſſendus*.		
22		56	12	The inlightned Part produced to the Chord between the Horns	19	58
23	17	02	45	The Chord between the Horns	32	12
24		8	20	The ſame repeated	30	28
25		10	39		29	56
26		13	00		28	31
27		15	29	The ſame again	27	33
28		17	37		26	35
29		19	35		25	36
30		21	47	The ſame again	24	38
31		23	24		23	39
32		24	54		22	40
33		26	27	The ſame again	21	41
34		27	57		20	42
35		29	08		19	43
36		30	20	The ſame again	18	44
37		31	07		17	45
38		32	04		16	46
39		32	50	The ſame again	15	47
40		34	12		13	48
41	17	35	20	The ſame again repeated	11	42

At 17^h. 39′. the Eclipſe was thought to be ended; and was viſibly ſo at 17^h. 41′: But by comparing the laſt Obſervations of the Chords between the Horns, it follows, that the true End of the Eclipſe was at 17^h. 38′. 20″. At 17^h. 43′ the Moon's Diameter was 33′ 40″.

The

The middle cannot be ſuppoſed to be very accurately determined by theſe Obſervations, which are not ſufficiently diſtant from the time of the greateſt Obſcuration. However by comparing ſeveral of them together, the middle will be obtained, *viz.*

	h	′	″
By Obſ. 3. compared with Obſ. 24. at	16	15	21
By Obſ. 4. compared with Obſ. 22. at	16	15	58
By Obſ. 5. compared with 19. and 20. at	16	16	00
By Obſ. 6. and 7 compared with 16. at	16	15	48

By reaſon of Clouds I could not ſee the Beginning of the Eclipſe, nor make ſuch Obſervations of the Moon's immerging into the Shadow, as I did of her emerging out of it.

By Obſervation 11. compared with Obſervation 15. the Digits eclipſed were $8\frac{1}{4}$.

The Angles were meaſured by a *Micrometer* in a 15 Foot Teleſcope: I have not conſidered how far they are conſiſtent with one another; they being ſet down here exactly, as they were firſt taken.

This Eclipſe is the more conſiderable, as happening very near the Moon's *Perigee*, and therefore uſeful to verify her *Anomaly*; as alſo to limit the greateſt Diameter of the Shadow of the Earth, and conſequently the Parallax of the Moon. This may very properly be compared with that of the 19th of *October*, 1697, whoſe middle was at 7h. 41′. P.M. at *London*, and Quantity the ſame as now.

The times by the Clock were 17′. 45″. ſooner than the apparent time, as were found by the following Obſervations of *Cor Leonis* and *Arcturus*, which through the Clouds were but juſt diſcernible.

Apparent Zenith Diſtance	Time by the Clock	Apparent Time by Calculat.	The Difference	
of Cor ♌				
° ′	h ′ ″	h ′ ″	′ ″	Mean Diff.
70 16 ½	13 32 43	13 50 35	17 52	′ ″
69 38	36 50	54 44	17 54	
69 09	40 06	57 51	17 45	17 50
68 40	43 09	14 00 59	17 50	
68 08	46 37	04 26	17 59	
of *Arcturus*.				
65 19	17 37 40	17 55 24	17 44	
65 06	39 12	56 48	17 36	
64 41	41 49	59 29	17 40	17 40
63 47	47 40	18 05 17	17 37	
			Clock to ſlow	17 45

The Latitude of *Wanſted* is 51°. 34′. Its Longitude is 8″ in time Eaſtward from the *Obſervatory* at *Greenwich*.

N. B. *The Account given of this Eclipſe by the Reverend Mr.* William Derham, *who obſerv'd it at* Upminſter, *is agreeable to this, as far as Clouds would permit him to obſerve.*

XXV.

Obſervations *on the* Heavens *at* Greenwich, 1711, 1712. *by Mr.* J. Flamſtead, n. 337. p. 65. — *of* Saturn.

Obſervationes SATURNI. 1711. 1712.

Temp. per Horolog.	Tempora correcta.	Die Veneris, Januarij 5. 1711.	Diſtantia a Vertice.
10 14 26	10 14 41	Calx Caſtoris μ ♊ tranſiit ——	28 50 10
11 11 38	11 11 53	In Inguine Pollucis, δ tranſiit ——	28 59 00
12 4 45	12 5 00	Saturnus tranſiit —— ——	30 23 20
		Aſcenſio Recta ♄ 119.01.00	
		Diſt. a Polo Bor. 68.55.20	
		Die Solis, Januarij 7.	
11 2 53	11 0 31	Geminorum δ tranſiit —— —	28 59 20
11 50 36	11 48 14	In pede Bor. ♋ μ tranſiit ——	29 5 20
11 55 22	11 53 00	Saturnus tranſiit —— ——	30 21 50
12 15 41	12 13 19	Cancri η *Bayero* tranſiit — —	30 4 30
12 26 18	12 23 56	Cancri γ, Aſellus Bor. tranſiit ——	28 59 50
		Aſcenſio Rect. ♄ 118.52.00	
		Diſt. a Polo Bor. 68.53.50	
		Die Lunæ, Januarij 8.	
10 58 35	10 57 49	Geminorum δ tranſiit —— —	28 59 15
11 50 46	11 50 00	Saturnus tranſiit — ——	30 20 35
12 11 25	12 10 30	Cancri η tranſiit —— ——	30 4 25
		Aſcenſio Rect. ♄ 118.46.30	
		Diſt. a Polo Bor. 68.52.35	
		Die Jovis, Januarij 25.	
9 45 53	9 46 26	Geminorum δ tranſiit — ——	28 59 10
10 32 27	10 33 00	Saturnus tranſiit —— ——	30 4 00
11 10 54	11 11 27	Cancri δ, Aſellus Auſt. tranſ. ——	32 17 50
		Aſcenſio Rect. ♄ 117.23.00	
		Diſt. a Polo Bor. 68.36.00	

Tem. per Horolog.	Tempora correcta.	Die Saturni, Januarij 25. 1711.		Diſtantia a Vertice
9 37 25	9 38 2	Geminorum ♂ tranſiit		28 59 20
10 13 11	10 13 48	Sub latere Pollucis *l* tranſiit		30 51 50
10 23 23	10 24 00	Saturnus tranſiit		30 2 30
10 40 59	10 41 36	Poſt Caudam ♋ *d* tranſiit		32 14 10
10 50 16	10 50 53	Cancri η tranſiit		30 4 35
		Aſcenſio Rect. ♄	117.14.00	
		Diſt. a Polo Bor.	68.34.30	
		Die Martis, Januarij 30.		
9 29 45	9 26 55	Geminorum ♂ tranſiit		28 59 40
10 14 50	10 12 00	Saturnus tranſiit		30 0 00
10 33 20	10 30 30	Cancri *d* tranſiit		32 14 10
10 42 35	10 39 45	Cancri η tranſiit		30 4 45
		Aſcenſio Rect. ♄	117.00.30	
		Diſt. a Polo Bor.	68.32.00	
		Die Mercurij, Feb. 28.		
8 18 32	8 15 00	Saturnus tranſiit		29 43 00
8 27 11	8 23 39	In Boreo pede Crancri μ tranſiit		29 5 40
9 2 50	8 59 18	Aſellus Boreus Cancri γ tranſiit		29 0 20
10 39 59	10 36 27	Lucida Colli Leonis γ tranſiit		30 12 05
		Aſcenſio Rect. ♄	115.31.30	
		Diſt. a Polo Bor.	68.15.00	
		Die Jovis, Mart. 1.		
8 14 5	8 11 00	Saturnus tranſiit		29 42 50
8 22 47	8 19 42	Cancri μ tranſiit		29 5 35
8 58 28	8 55 23	Aſellus Boreus tranſiit		29 0 15
10 35 36	10 32 31	Lucida Colli Leonis tranſiit		30 12 00
		Aſcenſio Rect. ♄	115.30.30	
		Diſt. a Polo Bor.	68.14.50	
		Die Veneris, Nov. 9.		
17 21 12	17 21 23	Sequens ad π Cancri tranſiit		35 21 10
17 29 49	17 30 00	Saturnus tranſiit		34 9 50
18 13 25	18 13 36	Auſtrina Colli Leonis η tranſiit		33 18 50
		Aſcenſio Rect. ♄	136.58.00	
		Diſt. a Polo Bor.	72.42.00	

Temp. per Horolog.	Tempora correcta.	Die Lunæ, Nov. 19. 1711.	Distantia à Vertice.
16 46 20	16 41 00	Saturnus transiit —— ——	34 8 00
16 59 31	16 54 11	Telescopica *a* transiit —— ——	33 45 30
17 29 59	17 24 33	Australina Colli Leonis η transiit ——	33 18 30
		Ascensio Rect. ♄ 136.58.30	
		Dist. a Polo Bor. 72.40.05	
		Die Jovis, Nov. 22.	
16 24 36	16 19 30	Cancri sequens ad π transiit ——	35 21 30
33 06	16 28 00	Saturnus transiit —— ——	34 6 50
46 27	16 41 21	Telescopica dicta transiit ——	33 45 10
17 16 51	17 11 45	Australina Colli Leonis transiit —— ——	33 18 30
		Ascensio Rect. ♄ 136.55.45	
		Dist. a Polo Bor. 72.39.00	
		Die Solis, Decembris 30.	
11 9 43	10 52 42	Lucidus pes ♊ γ transiit —— ——	34 51 30
13 29 25	13 12 24	Cancri præced. ad ο transiit —— ——	35 4 00
13 49 01	13 32 00	Saturnus transiit —— ——	33 30 00
14 39 50	14 22 49	Lucida Colli Leonis transiit ——	33 18 40
		Ascensio Rect. ♄ 134.10.00	
		Dist. a Polo Bor. 72. 2. 5	
		Die Saturni, Januarij 12. 1712.	
11 39 52	11 33 06	Ad caudam Cancri ζ transiit —— ——	32 59 10
12 40 46	12 34 00	Saturnus transiit —— —— ——	33 12 00
12 43 16	12 36 30	Cancri sequens ad π transiit —— ——	35 22 20
13 36 44	13 29 58	Cor Leonis transiit —— ——	38 6 55
		Ascensio Rect. ♄ 134.12.00	
		Dist. a Polo Bor. 71.44.00	
		Die Saturni, Jan. 19.	
11 45 31	11 36 55	Asellus Australinus transiit —— ——	32 17 10
11 58 14	49 38	Australina ad ο Cancri transiit —— ——	35 3 50
12 11 36	12 3 00	Saturnus transiit —— —— ——	33 2 5
12 20 00	11 24	Telescopica *b* transiit —— ——	32 33 20
		Ascensio Rect. ♄ 133.37.00	
		Dist. a Polo Bor. 71 34.10	

Temp. per Horolog.	Tempora correcta.	Die Solis, Jan. 27. 1712.	Distantia a Vertice.
10 57 50	11 4 31	Asellus Australis transiit ——	32 17 10
11 10 54	11 17 35	Borea ad *o* Cancri transiit ——	34 48 10
11 21 19	12 28 00	Saturnus transiit —— ——	32 50 20
11 32 20	39 01	Telescopica *b* transiit ——	32 33 25
		Ascensio Rect. ♄ 132.58.00	
		Dist. a Polo Bor. 71.22.20	
		Die Lunæ, Martii 31.	
7 8 46	7 7 41	Asellus Australis transiit — —	32 16 50
7 20 35	7 19 30	Saturnus transiit —— ——	32 03 30
7 36 50	7 35 45	Cancri præced. ad π transiit ——	35 19 10
7 39 36	7 38 31	Sequens ad π transiit — — —	35 21 20
8 31 51	8 30 46	Australis colli Leonis transiit —	33 18 40
		Ascensio Rect. ♄ 130.02.00	
		Dist. a Polo Bor. 70.35.30	
		Die Veneris, Novemb. 7.	
18 17 13	18 22 00	Saturnus transiit —— ——	37 57 30
18 26 13	18 31 00	Leonis 40 *Catal. Brit.* transiit ——	41 14 10
18 28 35	18 33 22	Ejusdem 41 transiit —— —	40 15 20
		Ascensio Rect. ♄ 150.15.30	
		Dist. a Polo Bor. 76.29.40	
		Die Lunæ, Nov. 17.	
17 33 19	17 34 59	Cor Leonis transiit —— —	38 7 20
17 42 20	17 44 00	Saturnus transiit —— ——	38 00 50
17 57 48	17 59 28	In Axilla Leonis *e* transiit ——	40 41 45
18 14 19	18 15 59	In ventre Leonis *l* transiit —— ——	39 24 50
		Ascensio Rect. ♄ 150.31.00	
		Dist. a Polo Bor. 76.33.00	

—*Of* Jupiter.

Observationes JOVIS. 1711.

		Die Saturni, Maij 26.	
12 44 28	12 39 44	Serpentarij 58 *Cat. Br.* transiit —	76 12 00
52 40	47 56	Sagittarij Nebulosæ *a* transiit ——	75 39 20
13 8 44	13 4 00	Jupiter transiit — — —	74 37 00
15 43	10 59	Sagittarij 11 transiit —— ——	72 5 20
		Ascensio Rect. ♃ 270.19.00	
		Dist. a Polo Bor. 113.11.50	

Die

Temp. per Horolog.	Tempora correcta.	Die Solis, Maij 27. 1711.	Diſtantia a Vertice.
10 47 24	10 43 2	Media frontis ♏, ♂ tranſiit ——	73 12 00
12 57 46	53 24	Teleſcopica *c* Jovem præced. ——	75 7 50
13 4 22	13 00 00	Jupiter tranſiit —— ——	74 36 50
11 53	7 31	Sagittarii 11 tranſiit — — —	72 5 20
		Aſcenſio Rect. ♃ 270.11.00	
		Diſt. a Polo Bor. 113.11.40	
		Die Solis, Junij 3.	
10 15 41	10 10 45	Media frontis Scorpii tranſiit ——	73 12 5
12 14 11	12 9 15	Nebuloſæ Sagittarii *b* tranſiit ——	75 10 20
12 17 09	12 12 13	Ejuſdem Nebuloſæ *a* tranſiit ——	75 39 30
12 28 56	12 24 00	Jupiter tranſiit —— ——	74 38 00
13 8 36	13 03 40	Sagit. in Oculo præced. tranſiit ——	74 29 15
		Aſcenſio Rect. ♃ 269.15.00	
		Diſt. a Polo Bor. 113.12.50	
		Die Lunæ, Junii 4.	
10 11 51	10 7 19	Media frontis Scorpii tranſiit ——	73 12 00
12 10 18	12 5 46	Nebuloſæ Sagittarii *b* tranſiit ——	75 10 20
12 24 32	12 20 00	Jupiter tranſiit —— ——	74 38 10
13 4 45	13 0 13	Præced. ad ν Sagittarii tranſiit ——	74 29 10
13 5 41	13 1 09	Sequens ad ν tranſiit —— ——	74 24 50
		Aſcenſio Rect. ♃ 269.07.00	
		Diſt. a Polo Bor. 113.13.00	
		Die Saturni, Junii 9.	
9 52 16	9 49 5	Media frontis Scorpii tranſiit ——	73 11 55
11 50 44	11 47 33	Nebuloſæ *b* tranſiit —— ——	75 10 15
12 2 11	11 59 00	Jupiter tranſiit —— ——	74 38 25
12 45 8	12 41 57	Præced. ad ν Sagittarii tranſiit ——	74 29 10
		Aſcenſio Rect. ♃ 268.25.00	
		Diſt. a Polo Bor. 113.13.15	
		Die Solis, Junii 10.	
9 48 22	9 44 38	Media frontis Scorpii tranſiit ——	73 12 00
11 46 51	11 43 07	Nebuloſæ *b* tranſiit —— ——	75 10 15
11 57 44	11 54 0	Jupiter tranſiit — — —	74 38 35
12 41 14	12 37 30	Præcedens ad ν Sagitt. tranſiit — —	74 29 15
		Aſcenſio Rect. ♃ 268.16.45	
		Diſt. a Polo Bor. 113.13.25	

Temp. per Horolog.	Tempora correcta.	Die Saturni, Julii 14. 1711.		Distantia a Vertice.
8 58 10	8 50 4	Serpentarii 48, C transiit		75 7 20
9 10 32	9 2 26	Ejusdem 54 sive D transiit		72 56 00
9 21 6	9 13 00	Jupiter transiit		74 37 50
9 40 49	9 32 43	Sagittarii in arcu μ transiit		72 31 30
		Ascensio Rect. ♃	264.12.30	
		Dist. a Polo Bor.	113.12.40	
		Die Solis, Julii 15.		
8 54 8	8 46 24	Serpentarii C transiit		75 7 20
9 6 28	8 58 44	Serpentarii D transiit		72 56 00
9 16 44	9 9 00	Jupiter transiit		74 37 50
9 36 46	9 29 2	Sagittarii μ transiit		72 31 35
		Ascensio Rect. ♃	264.07.45	
		Dist. a Polo Bor.	113.12.40	
		Die Jovis, Julii 3. 1712.		
11 36 3	12 25 14	Capric. sub Oculo σ transiit		71 24 40
12 44 6	12 35 17	Capric. in rostro π transiit		70 33 00
12 45 42	12 34 53	Capricorni ϱ transiit		70 09 50
12 57 49	12 47 00	Jupiter transiit		71 26 20
13 16 24	13 5 35	Capric. 20 *Catal. Brit.* transf.		71 33 10
		Ascensio Rect. ♃	306.09.20	
		Dist. a Polo Bor.	110. 0.30	
		Die Martis, Julii 15.		
11 39 34	11 39 33	Capricorni σ transiit		71 24 45
55 1	11 55 00	Jupiter transiit		71 49 20
12 19 53	12 19 52	Capricorni 20 transiit		71 33 10
24 38	12 24 57	Usni in medio corpore η transf.		72 23 25
		Ascensio Rect. ♃	304.34.35	
		Dist. a Polo Bor.	110.23.30	
		Die Mercurii, Sept. 17.		
7 32 37	7 31 56	Telesc. Jovem præced. transf.		72 40 40
7 38 41	7 38 00	Jupiter transiit		72 51 10
7 42 28	7 41 37	Telesc. Jovem sequens transf.		73 14 40
		Ascensio Rect. ♃	299.43 00	
		Dist. a Polo Bor.	111.25.30	
		Die Veneris, Septembris 19.		
7 30 55	7 32 00	Jupiter transiit		72 50 45
8 19 47	8 20 52	Capricorni η transiit		72 23 40
		Ascensio Rect. ♃	299.45.00	
		Dist. a Polo Bor.	111.25.05	

Temp. per Horolog.	Tempora correcta.	Die Lunæ, Octobris 6. 1712.	Diſtantia a Vertice.
6 25 35	6 31 30	Jupiter tranſiit —— ——	72 39 50
6 36 22	6 42 17	Capricorni in roſtro o tranſiit ——	70 56 25
6 46 36	6 52 31	Capricorni in Cervice υ tranſ.	70 33 30
		Aſcenſio Rect. ♃ 300.39.00	
		Diſt. a Polo Bor. 111.14.10	

Obſervationes MARTIS. 1711.

Die Solis Jan. 7.

12 40 35	12 38 56	Cancri Auſt. ad o tranſiit —— —	35 04 00
12 40 56	12 39 17	Cancri Bor. ad o tranſiit --——	34 48 00
12 58 45	12 57 6	Cancri ſequens ad π tranſiit ——	35 21 20
13 27 15	13 25 36	Leonis ♆ tranſiit—— ——	36 8 50
13 50 52	13 49 13	Auſtrina Colli Leonis η tranſiit ——	33 19 00
14 00 39	13 59 00	Mars tranſiit —— ——	34 51 30
14 30 14	14 28 35	Borea Ventris ♌, *k* tranſiit ——	35 45 40
		Aſcenſio Rect. ♂ 150.20.00	
		Diſt. a Polo Bor. 73.23.35	

Die Saturni, Januarij 27.

10 40 59	10 41 30	Cancri 20, prima ad *d* tranſiit —	32 14 10
10 50 16	10 50 47	Cancri η tranſiit —— ——	30 4 35
12 8 29	12 9 00	Mars tranſiit —— ——	32 14 00
12 25 27	12 25 58	Auſtrina colli Leonis η tranſ.——	33 19 00
12 37 59	12 38 30	Lucida colli Leonis γ tranſ. -——	30 11 50
		Aſcenſio recta ♂ 143.37.00	
		Diſt. a Polo Bor. 70.36.00	

Die Lunæ, Januarij 29.

12 1 50	11 59 00	Mars tranſ. — —— ——	31 58 50
12 21 58	12 19 08	Leonis η tranſ.--—— — ——	33 19 05
12 34 31	12 31 41	Lucida colli Leonis γ tranſ. ——	30 11 50
		Aſcenſio Rect. ♂ 142.49.30	
		Diſt. a Polo Bor. 70.30.50	

Die

Tem. per Horolog.	Tempora correcta.	Die Martis, Jan. 30. 1711.	Diſtantia a Vertice
10 33 30	10 30 25	Cancri 20, prima ad *d* tranſ.	32 14 10
10 42 35	10 39 30	Cancri η tranſiit	30 4 45
11 56 5	11 53 00	Mars tranſ.	31 51 35
12 17 49	12 14 44	Leonis η tranſ.	33 19 5
12 30 20	12 27 15	Leonis γ tranſ.	30 11 50
		Aſcenſio Rect. ♂ 142.25.00	
		Diſt. a Polo Bor. 70.23.35	
		Die Mercurii, Feb. 28.	
8 27 11	8 23 58	In pede Bor. Cancri μ tranſ.	29 5 40
9 2 50	8 59 37	Aſellus Boreus γ tranſ.	29 00 20
9 31 13	9 28 00	Mars tranſ.	30 5 10
10 27 28	10 24 15	Leonis η tranſ.	33 19 55
10 39 39	10 36 26	Leonis γ tranſ.	30 12 5
		Aſcenſio Rect. ♂ 133.45.00	
		Diſt. a Polo Bor. 68.37.10	
		Die Jovis, Martij 1.	
8 22 47	8 19 27	Cancri μ tranſiit	29 5 35
8 58 28	8 55 8	Aſellus Boreus tranſiit	29 00 15
9 26 20	9 23 00	Mars tranſiit	30 6 20
10 23 04	0 19 44	Leonis η tranſ.	33 19 50
10 35 36	10 32 16	Lucida colli Leonis tranſ.	30 12 00
		Aſcenſio Rect. ♂ 133.37.30	
		Diſt. a Polo Bor. 68.38.20	
		Die Lunæ, Novemb. 17. 1712.	
18 21 7	18 19 52	Leonis 55 *Catal. Brit.* tranſ.	43 45 40
18 25 53	18 24 38	Sub Ventre Leonis *c* tranſ.	43 49 40
18 30 14	18 28 59	Leonis χ tranſ.	42 35 10
18 43 15	18 42 00	Mars tranſiit	43 7 25
		Aſcenſio Rect. ♂ 165.48.00	
		Diſt. a Polo Bor. 81.39.45	
		Die Jovis, Novemb. 20.	
18 13 8	18 6 40	Leonis 55 tranſiit	43 45 40
18 17 53	18 11 25	Leonis 58, *c* tranſiit	43 49 50
18 22 14	18 15 46	Leonis χ tranſiit	42 35 15
18 38 18	18 31 50	In poplite Leonis σ tranſ.	43 52 10
18 40 28	18 34 00	Mars tranſiit	43 36 55
		Aſcenſio Rect. ♂ 167. 6.30	
		Diſt. a Polo Bor. 82. 9.15	

Obſer-

Observationes SOLIS. 1711.	Distantia a Vertice.
Die Saturni, Januarii 6.	
Solis centro per planum Arcus Meridionalis transeunte, limbus ejus remotus & australis distabat a Vertice	72 31 10
Die Veneris, Januarii 26.	
Solis Meridiani limbus proximus a Vertice	66 35 10
Die Martis, Januarii 30.	
Solis limbus proximus a Vertice	65 38 40
Die Lunæ, Junii 4.	
Solis limbus remotus, &c.	28 24 18
Die Saturni, Julii 14.	
Solis limbus remotus	31 55 20
Die Martis, Novembris 20.	
Solis limbus remotus	73 30 40
Die Martis, Decembris 4.	
Solis limbus remotus a Vertice	74 59 30
Die Mercurii, Januarii 2. 1712.	
Solis limbus remotus a Vertice	73 17 30
Die Saturni, Januarii 12.	
Solis limbus remotus	71 18 00
Die Veneris, Martii 7.	
Solis limbus remotus	52 31 00
Die Veneris, Maii 9.	
Solis limbus remotus	31 40 50
Die Martis, Octobris 7.	
Solis limbus remotus a Vertice	61 29 50

—of the Sun.

Observationes LUNÆ. 1711.

—of the Moon.

Temp. per Horolog.	Tempora correcta.	Die Saturni, Maii 19. 1711.	Distantia a Vertice.
10 22 12	10 18 32	Scorpii γ sive Libræ 15 transiit	75 32 50
10 50 55	10 47 15	☽ Limbus transiit centro a Vert.	75 38 40
10 52 10	10 48 30	☽ centrum transiit proximo	75 22 00
11 8 30	11 4 50	Scorpii *b* transiit	76 15 20
11 11 10	11 7 30	Scorpii A transiit	75 50 55
		Ascensio Recta ☽ 229.18.30	
		Dist. a Polo Bor. 114.13.40	

Temp. per Horolog.	Tempora correcta.	Die Lunæ, Novemb 19. 1711.	Diſtantia a Vertice.
16 41 28	16 36 8	Lunæ centrum tranſiit remoto ——	37 6 30
17 42 16	16 36 56	Lunæ limbus tranſiit centro ——	36 52 30
16 46 20	16 41 00	Saturnus tranſiit —— ——	34 8 00
16 59 31	16 54 11	Stella Teleſcopica *a* tranſiit ——	33 45 30
17 29 53	17 24 33	Auſtr. Colli Leonis η tranſiit ——	33 18 30
		Aſcenſio Rect. ☽ 135.41.40	
		Diſt. a Polo Bor. 75.23.20	
		Die Saturni, Januarii 12. 1712.	
7 40 50	7 34 00	Medium Eclipſis Lunaris, quo tempore Chorda partis in Luna deficientis erat 24. 30; maximus autem defectus 8. 30 a parte Borea. Lunæ Diam. 30.48	
11 39 52	11 33 6	Cancri ζ *Bayero* tranſ —— —	32 59 10
12 13 46	12 7 00	☽ centrum tranſiit remoto ——	34 14 10
40 46	12 34 00	Saturnus tranſiit — — —	33 12 00
43 16	12 36 30	Cancri ſequens ad π tranſiit —	35 22 20
13 36 44	13 29 58	Cor Leonis tranſiit —— ——	38 6 55
		Aſcenſio Rect. ☽ 127.25.30	
		Diſt. a Polo Bor. 71.31.00	
		Die Jovis, Martii 6.	
7 39 8	7 38 8	π 80 *Catal. Brit.* tranſiit ——	30 29 30
7 49 42	7 48 42	Geminorum 86 *l* tranſiit ——	30 51 45
7 54 45	7 53 45	Lunæ limbus tranſiit, centro ——	30 50 40
7 55 48	7 54 48	☽ centrum tranſiit, proximo ——	30 35 30
8 1 41	8 0 41	Nona Cancri μ tranſiit —— —	29 4 55
		Aſcenſio Rect. ☽ 116.14.40	
		Diſt. a Polo Bor. 69.22.50	
		Die Mercurii, Maii 7.	
9 47 38	9 46 2	Virginis 70 *Catal. Brit.* tranſiit ——	66 9 50
9 48 48	9 47 12	Virginis 71 tranſiit —— —	65 45 30
9 52 51	9 51 15	Ejuſdem 75 tranſiit — — —	68 7 40
10 9 36	10 8 00	Lunæ limbus tranſiit, centro —	69 12 30
10 10 43	10 9 7	Lunæ centrum tranſiit, remoto —	69 28 35
		Aſcenſio Rect. ☽ 208. 4.30	
		Diſt. a Polo Bor. 107.45.50	

Die

Temp. per Horolog.	Tempora correcta.	Die Jovis, Maii 8. 1712.	Distantia a Vertice.
10 52 2	10 50 00	Libræ 8 *Catal. Brit.* transiit ——	74 51 50
11 1 35	10 59 33	Scorpii γ sive Libræ 15 transiit —	75 32 30
11 8 2	11 6 00	Lunæ limbus transiit, centro ——	73 42 30
11 09 16	11 7 14	Lunæ centrum transiit, remoto ——	73 58 20
11 50 33	11 48 31	Scorpii A transiit —— ——	75 51 10
11 57 34	11 55 32	Media frontis ♏ δ transiit ——	73 12 10
		Ascensio Recta ☽ 223.45 00	
		Dist. a Polo Bor. 112.16.10	
		Die Saturni, Maii 10.	
12 18 05	12 16 30	Cor Scorpii *Antares* transiit ——	77 10 00
13 3 48	13 2 13	Serpentarii A transiit —— ——	77 32 50
13 18 13	13 16 38	Lunæ centrum transiit, remoto —	78 1 30
13 19 30	13 17 55	Lunæ limbus transiit, centro ——	77 46 05
13 35 25	13 33 50	Prima Sagittarii ρ transiit ——	79 4 20
14 16 8	14 14 33	Sagittarii λ transiit —— ——	76 57 00
		Ascensio Rect. ☽ 258.03.20	
		Dist. a Polo Bor. 116.20.15	

In Exemplari Observationum Anni 1712, a *D. Flamsteedio* ad Regiam Societatem misso, Observatoris nomen in titulo erasum esse videtur; & ipso sic præcipiente, ad calcem subscripta sunt hæc verba,

Obs. & Transcripsit Jos. Crosthwaite.

Observationes SATURNI, 1713.

XXVI.

Observations *on the* Heavens, 1713. *at* Greenwich, n. 344. p. 285. — *of* Saturn.

Temp. per Horolog.	Tempora correcta.	Die Solis, Januarii 25.	Distantia a Vertice.
h. ′ ″	h. ′ ″		° ′ ″
8 30 15	8 28 5	Geminorum πρόπους transiit ——	28 13 20
8 41 7	38 57	Pes Castoris η transiit —— ——	28 54 50
8 49 8	8 46 58	Calx ejusdem sive μ transiit ——	28 50 40
12 10 49	12 8 39	Leonis ψ *Bayero* transiit ——	36 9 30
12 25 24	23 14	Leonis ν transiit —— ——	37 40 30
12 34 21	32 11	Saturni centrum transiit —— —	36 51 45
12 35 44	12 33 34	Cor Leonis transiit —— ——	38 7 00
		Ascensio Rect. ♄ 147.55.10	
		Dist. a Polo Bor. 75.23.55	
		Longitudo ♌ 25. 8.15	
		Latitudo Bor. 1.31.27	

Tem. per Horolog.	Tempora correcta.	Die Jovis, Februarii 5. 1713.		Diſtantia a Vertice.
h. ′ ″	° ′ ″			h. ′ ″
11 20 52	11 14 10	Leonis ξ *Bayero* tranſiit		38 55 20
30 9	23 27	Leonis o tranſiit		40 17 30
35 18	28 36	Leonis 16ta *Cat. Brit.* tranſiit		38 21 20
47 8	40 26	Leonis ν tranſiit		37 40 30
52 42	46 00	Saturni centrum tranſiit		36 32 50
11 57 25	50 43	Cor Leonis tranſiit		38 7 5
12 0 35	53 53	Leonis 31ma tranſiit		36 42 50
5 40	11 58 58	Leonis 34ta tranſiit		36 19 30
12 10 50	12 4 8	Leonis 38va tranſiit		35 3 50
		Aſcenſio Recta ♄	147. 4.45	
		Diſt. a Polo Bor.	75. 5.00	
		Longitudo ♌	24.14. 8	
		Latitudo Bor.	1.32.16	
		Die Veneris, Februarii 6.		
8 22 53	8 14 43	Lucidus pes Pollucis, ♊ γ tranſiit		34 52 00
11 29 22	10 21 12	Leonis ψ tranſiit		36 9 15
11 43 58	11 35 48	Leonis ν tranſiit		37 40 30
11 49 10	11 41 0	Saturni centrum tranſiit		36 31 00
		Aſcenſio Recta ♄	146.59. 0	
		Diſtantia a Polo	75. 3.10	
		Longitudo ♌	24. 8.17	
		Latitudo Bor.	1.32. 8	
		Die Mercurii, Feb. 18.		
11 0 15	10 53 0	Saturni centrum tranſiit		36 12 00
11 8 53	11 1. 38	Cor Leonis tranſiit		38 7 5
11 17 7	11 9 52	Leonis 34ta *Cat. Brit.* tranſiit		36 19 35
11 22 16	11 15 1	Ejuſdem 38va tranſiit		35 3 55
		Aſcenſio Recta ♄	146. 5.00	
		Diſt. a Polo	74.44.10	
		Longitudo ♌	23.12.47	
		Latitudo Bor.	1.32.41	
		Die Lunæ, Martii 2.		
10 6 30	9 52 3	Leonis ψ tranſiit		36 9 30
19 27	10 5 00	Saturni centrum tranſiit		35 55 20
31 21	16 54	Cor Leonis tranſiit		38 7 5
34 31	20 4	Leonis 31ma tranſiit		36 42 50
10 39 35	10 25 8	Leonis 34ta tranſiit		36 19 40
		Aſcenſio Recta ♄	145.16.00	
		Diſtantia a Polo	74.27.30	
		Longitudo ♌	22.22.40	
		Latitudo Bor.	1.23.52	

Temp. per Horolog.	Tempora correcta.	Die Martis, Aprilis 7. 1713.		Diſtantia a Vertice.
h. ′ ″	h. ′ ″			° ′ ″
7 43 1	7 41 15	Leonis ♆ tranſiit		36 9 25
50 46	7 49 00	Saturni centrum tranſiit		35 31 10
57 36	55 50	Leonis ν *Bayero* tranſiit		37 40 20
8 6 39	8 4 53	Leonis in collo η tranſiit		33 19 25
16 7	14 21	Ejuſdem 34ta *Cat. Brit.* tranſiit		36 19 30
8 21 17	8 19 31	Ejuſdem 38va tranſiit		35 3 50
		Aſcenſio Recta ♄	143·57·45	
		Diſtantia a Polo	74. 3.15	
		Longitudo ♌	21. 3.32	
		Latitudo	1.21.20	
		Die Mercurii, Aprilis 8.		
7 47 43	7 46 00	Saturni centrum tranſiit		35 31 15
54 34	52 51	Leonis ν tranſiit		37 40 20
8 3 37	8 1 54	Leonis η tranſiit		33 19 20
13 4	11 21	Leonis 34ta tranſiit		36 19 35
8 18 14	8 16 31	Leonis 38va tranſiit		35 3 45
		Aſcenſio Recta ♄	143.57.30	
		Diſtantia a Polo	74. 3.20	
		Longitudo Jov. ♌	21. 3.20	
		Latitudo	1.31.10	
		Saturno pene ſtationario		
		Die Jovis, Novemb. 5.		
18 22 00	18 15 37	Leonis π in genu ſeq. tranſiit		42 4 00
30 8	23 45	Cor Leonis tranſiit		38 7 5
54 35	48 12	Leonis in Axilla ρ tranſiit		40 42 0
19 11 5	19 4 42	Leonis in ventre ι tranſiit		39 25 15
19 26 23	19 20 00	Saturni centrum tranſiit		42 10 40
		Aſcenſio Recta ♄	162.23.20	
		Diſtantia a Polo	80.43.00	
		Longitudo ♍	10.13.40	
		Latitudo Bor.	1.39.37	

Obſer-

—*Of* Jupiter.

Observationes JOVIS. 1713.

Tem. per Horolog.	Tempora correcta.	Die Solis Auguſti. 9.	Diſtantia a Vertice
h. ′ ″	h. ′ ″		° ′ ″
12 40 4	12 37 27	Aquarii λ in effuſione Aquæ tranſiit	60 32 50
12 48 37	12 46 0	Jovis centrum tranſiit	60 48 35
12 52 36	12 49 59	Aquarii 73ta *Cat. Brit.* prima ad *h* tranſ.	60 46 20
13 4 21	13 1 44	Aquarii in aqua χ tranſiit	60 49 10
		Aſcenſio Rect. ♃ 341.33. 5	
		Diſt. a Polo Bor. 99.21.40	
		Longitudo ♓ 9.26.00	
		Latitudo Auſt. 1.25.08	
		Die Lunæ, Auguſti 10.	
12 36 21	12 33 55	Aquarii λ tranſiit	60 32 50
12 44 26	12 42 00	Jovis centrum tranſiit	00 52 00
12 48 53	12 46 27	Aquarii 73ta tranſiit	
		Aſcenſio Rect. ♃ 341.26. 5	
		Diſtant. a Polo 99.25. 5	
		Longitudo Jov. ♓ 9.18.17	
		Latitudo Auſt. 1.25 40	
		Die Lunæ, Octobris 26.	
7 29 16	7 28 42	Aquarii in Clune σ tranſiit	63 34 40
7 36 34	7 36 0	Jovis centrum tranſiit	63 00 5
8 14 34	8 14 0	Aquarii 80ma prima ad ♆ tranſiit	62 5 20
8 17 45	8 17 11	Aquarii 84ta ſeq. ad ♆ tranſiit	62 37 5
		Aſcenſio Recta ♃ 335.41.30	
		Diſtantia a Polo 101.33.20	
		Longitudo Jovis ♓ 3.16.00	
		Latitudo Auſt. 1.19. 8	
		Die Martis, Octob. 27.	
7 25 40	7 23 34	Aquarii Clunis σ tranſiit	63 34 35
7 33 6	7 31 00	Jovis centrum tranſiit	62 59 15
8 11 00	8 8 54	Aquarii prima ad ♆ tranſiit	62 5 15
8 14 10	8 12 4	Sequens ad ♆ tranſiit	62 37 10
		Aſcenſio Recta ♃ 335.43.20	
		Diſt. a Polo 101.32.30	
		Longitudo ♓ 3.17.58	
		Latitudo Auſt. 1.19.00	

Temp. per Horolog.	Tempora correcta.	Die Jovis, Octob. 29. 1713.	Distantia a Vertice.
h. ′ ″	h. ′ ″		° ′ ″
7 18 29	7 15 19	Aquarii σ transiit —— ——	63 34 40
26 10	7 23 00	Jovis centrum transiit —— ——	62 57 20
8 3 47	8 0 37	Prima ad ♄ transiit — ——	62 5 20
6 55	8 3 45	Sequens ad ♄ transiit —— —	62 37 10
		Ascensio Recta ♃ 335·47·45	
		Distantia a Polo 101.30.35	
		Longitudo Jov. ♓ 3.22.41	
		Latitudo Aust. 1.18.49	

Observationes MARTIS. 1713. —*of* Mars.

		Die Mercurii, Feb. 18.	
12 28 38	12 21 20	Leonis in poplite τ transiit ——	47 2 15
12 51 6	12 43 48	In ancone Alæ ♍ β transiit ——	48 5 40
13 10 21	13 3 3	Virginis 10ma *Cat. Brit.* r transiit —	47 57 40
13 13 18	13 6 00	Martis centrum transiit ——	47 2 5
13 21 8	13 13 50	In cervice Virginis c transiit ——	46 33 30
		Ascensio Rect. *Martis* 179.29.20	
		Distantia a Polo 85.34.35	
		Longitudo ♍ 27.46.00	
		Latitudo Bor. 3.51.10	
		Die Martis, Martii 3.	
11 55 52	11 53 2	In vertice Virginis ν transiit ——	43 20 00
12 4 50	12 2 00	Martis centrum tranfiit ——	45 14 20
10 54	8 4	In vultu Virginis π transiit ——	43 15 25
20 8	17 18	Undecima Virginis s transiit ——	44 3 30
12 30 25	27 35	Virginis 16 in cervice c transiit —	46 33 25
12 32 37	12 29 47	Virginis 17ma *Cat. Brit.* transiit —	44 33 45
		Ascensio Rect. *Martis* 175. 1.15	
		Dist. a Polo Bor. 83.46.45	
		Longitudo ♍ 22.57.33	
		Latitudo Bor. 3.43.37	

Die

Temp. per Horolog.	Tempora correcta.	Die Martis, Aprilis 7. 1713.		Diſtantia a Vertice.
h. ′ ″	h. ′ ″			° ′ ″
9 4 47	9 3 10	Sub ventre Leonis χ tranſiit	——	42 35 25
9 17 37	9 16 00	*Martis* centrum tranſiit	——	42 42 50
9 38 10	9 36 33	Prima Virg. *Cat. Brit.* ω tranſiit	——	41 44 50
9 45 00	9 43 23	Borea in Vertice ♍ ξ tranſiit	——	41 37 15
		Aſcenſio Recta *Martis*	165.45.40	
		Diſtantia a Polo	81.15.10	
		Longitudo *Martis* ♍	13.30.40	
		Latitudo Bor.	2.26.31	
		Die Mercurii, Aprilis 8.		
9 1 44	9 0 29	Leonis χ tranſiit	——	42 35 30
9 14 15	9 13 00	*Martis* centrum tranſiit	——	42 43 40
9 35 7	9 33 52	Virginis ω tranſiit	——	41 44 55
9 41 58	9 40 43	Virginis ξ tranſiit	——	41 37 15
		Aſcenſio Recta *Martis*	165.41.00	
		Diſtantia a Polo	81.16.00	
		Longitudo *Martis* ♍	13.26.45	
		Latitudo Bor.	2.23.58	
		Die Veneris, Maii 1.		
7 55 9	7 50 00	*Martis* centrum tranſiit	——	44 17 30
8 18 12	8 13 3	In Vertice Virginis ν tranſiit	——	43 20 00
8 33 14	8 28 5	In Vultu Virginis π tranſiit	——	43 15 30
		Aſcenſio Recta *Martis*	166.59.40	
		Diſtantia a Polo	82.49.50	
		Longitudo ♍	15.15.00	
		Latitudo Bor.	1.27.40	
		Die Saturni, Maii 2.		
7 52 45	7 47 00	*Martis* centrum tranſiit	——	44 24 20
8 15 7	8 9 22	Virginis ν tranſiit	——	43 20 5
8 30 8	8 24 23	Virginis π tranſiit	——	43 15 25
		Aſcenſio Recta *Martis*	167.10.00	
		Diſtantia a Polo	82.56.40	
		Longitudo ♍	15.27. 5	
		Latitudo Bor.	1.25.20	

Obſer-

Obſervationes LUNÆ. 1713.

—*of the* Moon.

Temp. per Horolog.	Tempora correcta.	Die Solis, Januarii 25. 1713.		Diſtantia a Vertice.
h. ′ ″	° ′ ″			h. ′ ″
8 9 33	8 7 23	Teleſcopica *a* tranſiit —— ——		28 26 20
8 15 5	8 12 55	Tauri 123ia *Cat. Brit.* tranſiit ——		27 2 30
8 20 20	8 18 10	Lunæ limbus præced. tranſiit, centro a Vertice		27 32 40
8 21 23	8 19 13	Lunæ centrum tranſiit, limbo remoto a Vertice		27 47 40
8 22 52	8 20 42	Lunæ cuſpis Bor. a Vertice ——		27 17 40
8 30 15	8 28 5	Geminorum προπὸς tranſiit ——		28 13 20
8 41 7	8 38 57	Pes Caſtorii η tranſiit —— ——		28 54 50
8 49 8	8 46 58	Calx ejuſdem μ tranſiit ——		28 50 40
		Aſcenſio Rect. cent. ☽	84.26.55	
		Diſtantia a Polo viſa	66. 4.40	
		Sed adhibit. Paral.	65.39.50	
		Longitudo Lunæ ♊	24.56.30	
		Latitudo Bor.	0.57.00	
		Die Lunæ, Januarii 26.		
8 26 41	8 24 36	Propus tranſiit —— ——		28 13 30
8 37 31	8 35 26	Pes Caſtoris η tranſiit —— ——		28 54 50
8 45 31	8 43 26	Calx Caſtoris μ tranſiit ——		28 50 40
9 9 43	9 7 38	Lunæ limbus præcedens tranſiit, centro a Vertice		28 45 00
9 10 50	9 8 45	Lunæ centrum tranſiit, limbo remoto a Vertice		29 0 5
9 12 30	9 16 25	Lunæ cuſpis Bor. a Vertice ——		28 30 10
9 27 50	9 25 45	♊orum 46ta *Cat. Brit.* tranſiit ——		28 26 10
9 42 44	9 40 39	♊orum in Inguine ♪ tranſiit ——		28 59 30
		Aſcenſio Rect. cent. ☽	97.43.50	
		Diſtantia a Polo viſa	67.17. 5	
		Adhibitâ Parallaxi	66.51.15	
		Longitudo Lunæ ♋	7. 6.18	
		Latitudo Auſt.	0. 8.48	

—*of* Jupiter's *Satellites.*

Obſervationes SATELLITUM JOVIS.

						Die Veneris, Octob. 30.
6	56	30	6	52	35	Quartus Satelles viſus eſt emergens ab umbra, diametro Jovis diſtans a *tertio* ei proximo ad dextram, Tubo ſcil. octo pedum.
7	4	00	7	00	0	Clare exſplenduit, & linea ducta a proximo illo per centrum Jovis emergentem reliquit ad Auſtrum, *ſitu ſcilicet inverſo.*
7	36	31	7	32	30	Pegaſi μ tranſiit per planum Arcus meridionalis.
						Die Saturni, Novemb. 7.
7	13	2	7	5	00	Secundus Satelles emergebat, vel potius emergere incipiebat. Tubo octo pedum.
9	5	11	8	57	00	Piſcium ♂ in Lino auſtrali tranſiit.

N. B. *Stella illa Teleſcopica* a, *quæ die Januarii* 25° *Lunam præceſſit, Aſcenſionem rectam tunc habuit* 81° 28′½, *& diſtabat a Polo* 66° 58′, 20″, *unde ſit Longitudo ejus* ♊ 22° 9′⅔ *cum Latitudine Auſtrali* 9° 13′½. *Hæc autem eſt ea ipſa ſtella ad quam applicabatur Jupiter in Statione ſecunda, anno* 1634. *Februarii* 6. *eamque non niſi tribus ſui corporis diametris ad auſtrum reliquit, obſervante* Gaſſendo: *ut habetur inter Obſervata ejus* pag. 174. *Et ad eandem* Mars *obſervatus eſt Septembris* 6^to^, *anno* 1644 *mane, ut videre eſt in Prolegomenis Selenographiæ* Hevelianæ pag. 65. *&* Fig. 1. *Multum autem conducet, ad accuratam Nodi Jovis determinationem, ejuſque motus, ſi modo inter ſtellas fixas planum orbitæ Jovialis non hæreat immobile. Etenim poſt decurſum* 83 *annorum, quibus Jupiter ſatis accurate ſeptem abſolvit periodos, anno ſcil.* 1717. *Januarii* 10. *mane, Planeta ſtellam illam corporaliter teget vel ſaltem ſtringet, ſpectaculo quidem raro neque hactenus quod ſciam Aſtronomis in Jove conceſſo.*

Vid. Infr. S. XXXI.

Stella autem ipſa, etiamſi Teleſcopica vocetur, ſudo cælo & abſente Lunâ inermis oculis aciem non fugit; comitemque habet ſequentem ad Auſtrum, & ſemidiametro Solis circiter diſtantem, apud quam conſpicietur Jupiter arctiſſime conjunctus, Die viceſimo Julii anni proximi 1716 *mane.*

Obſervations *of the* Occultations *of the* fixt Stars *by the* Moon, *uſeful for finding the* Longitude, *by* — n. 354. p. 693.

XXVII. Of all the Methods hitherto propoſed for finding the *Longitudes* of Places for Geographical Uſes, none ſeems more adapted to the Purpoſe, than that by the *Occultations* of the fixed Stars by the *Moon* obſerved in diſtant Places: For thoſe Immerſions of the Stars, which happen on the dark Semicircle of the Moon, and their Emerſions from the ſame, are perfectly momentaneous, without that Ambiguity, to which the Obſervations of the Eclipſes of the *Moon*, and thoſe of *Jupiter*'s *Satellites* are ſubject. Beſides, whilſt the Moon is horned, and her weaker Light leſs dazzling, an ordinary ſhort Teleſcope,

ſuch as is found to be manageable on Shi›-board, ſuffices to obſerve thoſe Moments, even in the Occultatio. of very minute Stars: On which Account, this way ſeems to bid faireſt for finding the Longitude at Sea. But ſince it would be needleſs to enquire exactly what Longitude a Ship is in, when that of the Port to which ſhe is bound is ſtill unknown; it were to be wiſht, that the Princes of the Earth would cauſe ſuch Obſervations to be made in the Ports, and on the principal Head-Lands of their Dominions, as might once for all ſettle truly the Limits of the Land and Sea. This Work however, being likely to be left to the Care of private Perſons, it may not be amiſs to give Notice of the preſent Opportunity of performing it, in this our Northern Hemiſphere, by means of the frequent Appulſes of the Moon, to the more Southerly of the *Hyades*, many of which ſhe eclipſes in each monthly Revolution, and will continue ſo to do, during the Years 1718, 1719 and 1720.

Theſe Stars are but three or four in all former Catalogues, but the *Britiſh* of Mr. *Flamſtead* encreaſes them to ſixteen; to them we have added three others ſomewhat ſmaller, *viz.* *c*, *i*, and *ϰ* in the Figure of the *Hyades* hereto annext. In it the principal Stars are markt with *Bayer*'s Marks, and the reſt with the Letters of the *Italick* Alphabet; their Longitudes are fitted to the Beginning of the Year 1718, and being truly laid down, may ſerve to inſtruct the Obſerver, when and where to look for them, when the Moon is among them. Fig. 121.

It appears by this Scheme, that the Diſtance between *a* and *α* or *Palilicium*, is about nine Hour's Motion of the Moon, in which time ſuppoſing her to paſs one to the other, ſhe muſt eclipſe *γ* and *e*, and four or five of thoſe about *θ*, and muſt apply very cloſe, with her Southern Limb, to all thoſe, which have about ſix Degrees South-Latitude; which would be a very entertaining Sight. But if the times of the Occultations of any one of theſe Stars, or even of any two of them in the ſame Night, be accurately obſerved under diſtant Meridians, the Difference of thoſe Meridians may be truly obtained thereby; eſpecially ſince the *Moon*'s *Parallax*, and all other Parts of her Theory thereto required, are at preſent ſufficiently ſtated and known.

For the Sake of ſuch, as are willing to make uſe of this Method, we have added the Places of all the *Hyades* fitted to the preſent time, and chiefly taken from the *Britiſh* Catalogue, which being faulty in the Stars we call *k* and *l*, we have here rectified them.

Catalogus Hyadrum, *ineunte Anno* 1718.

Stellarum NOMINA		Long. ♊			Lat. Auſt.			Ma.
Quæ præcedit γ Tauri —— ——	a	0	51	3	5	50	14	7
In naribus Tauri, Bayero	γ	1	50	54	5	46	22	3
Quæ ſub γ —— —— ——	b	1	56	31	6	19	57	7
In Origine Naſi Tauri —— ——	c	2	54	25	4	47	5	7
Inter nares & oculum Tauri Boreum —	δ	2	54	47	4	0	34	¾
Huic contigua ad Auſtrum —— ——	d	3	10	33	4	9	4	6
Præcedentium θ Borealis —— ——	e	3	17	21	5	41	50	8
Earum Auſtralis clarior —— ——	f	3	25	32	6	2	44	6
Quæ ſequitur δ —— ——	g	3	35	2	3	43	27	5
Contiguarum inter nares & Palilicium Borea	θ	3	59	45	5	47	16	4
Earundem Auſtralior —— ——	θ	4	0	11	5	52	55	4
Duarum ſupra θ Borea —— ——	h	4	2	32	5	23	43	7
Earundem Auſtralior —— ——	i	4	7	44	5	36	40	8
Sub θ trium in recta præcedens —— —	k	4	19	27	6	9	45	4/7
Earum media —— —— ——	l	4	26	55	6	7	35	4/7
2^{rum} *θ ſequentium Borea* —— ——	m	4	30	26	5	37	49	7
Oculus Boreus Tauri —— ——	ε	4	30	31	2	35	58	3
Sequentium θ Auſtralis —— ——	n	4	32	35	5	41	00	8
Trium ſub θ ſequens —— —— —	o	4	45	55	6	0	35	7
Palilicium Bayero	α	5	50	20	5	29	50	1
Quæ hanc ſequitur proxime —— ——	p	6	17	35	6	3	20	7
Contig. ſequentium Auſtralis —— —	q	6	30	34	6	19	19	6
Borea & clarior —— ——	σ	6	33	12	6	12	35	7

An Account of the Cauſe *of* Venus *being* ſeen *in the* Day-time, *by Dr.* E. Halley, n.349. p.466.

XXVIII. The late Appearance of *Venus* in the *Day-time*, for many Days together, was generally taken Notice of about *London*, and elſewhere; and by ſome reckoned to be Prodigious. This put me upon the Enquiry, how it came to paſs, that at that time the *Planet* ſhould be ſo plainly ſeen by Day; whereas ſhe rarely ſhews herſelf ſo, unleſs to thoſe, who know exactly where to look for her. To reſolve this, the following Problem aroſe, *viz.* To find the Situation of the *Planet* in reſpect of the *Earth*, when the *Area* of the illuminated Part of her Diſk is a *Maximum*.

To

To inveſtigate this *Maximum*, I found it requiſite to aſſume the following *Lemmata*. I. That the viſible *Areas* of the Diſk of the ſame *Planet*, at differing Diſtances, are always reciprocally as the Squares of thoſe Diſtances; which is evident from the firſt Principles of Opticks. II. That the *Area* of the whole Diſk of the *Planet* is to the *Area* of the enlightned Part thereof, as the Diameter of a Circle to the Verſed-Sine of the exteriour Angle at the *Planet*, in the Triangle, at whoſe Angles are the *Sun*, *Earth*, and *Planet*. III. That in all plain Triangles, four times the Rectangle of the Sides containing any Angle, is to be the Exceſs of the Square of the Sum of the Sides above the Square of the Baſe, as the Diameter is to the Verſed-Sine of the Complement of the contained Angle to a Semicircle, which I call the exteriour Angle: This is a new *Theorem* of good Uſe in *Trigonometry*, and is eaſily to be proved from the 12th and 13th of the II. *Elem. Euclid.*

This premiſed, putting m for the Diſtance of the *Sun*, and *Earth*, and n for that of the *Sun* and *Venus*, and x for the Diſtance of the *Earth* and *Venus*, or the third Side of the Triangle which we ſeek; by the third *Lemma*, $4nx$, will be to the Exceſs of the Square of $n+x$ above the Square of m, as the *Area* of the whole Diſk of *Venus* to the *Area* of the Part enlightned; and by the *firſt Lemma*, the *Area's* of her whole Diſk, are at all times as the Squares of x reciprocally; whence the Quantity $\frac{nn+2nx+xx-mm}{4nx^3}$ will in all Caſes be proportional to the Area of the enlightned Part.

Now that this ſhould be a *Maximum*, it is required that the Fluxion thereof be equal to o, or that the negative Parts thereof be equal to the Affirmative; that is, that $2nx\dot{+}2x\dot{x}\times 4nx^3 = 12nx^2\dot{x}\times \overline{nn+2nx+xx-mm}$; and dividing all by $4nx^3\dot{x}$, the Equation becomes $2nx+2xx=3nn+6nx+3xx-3mm$. Conſequently $3nn+4nx+xx=3mm$, and therefore $x=\sqrt{3mm+nn}-2n$.

From hence a ready and not inelegant Geometrical Conſtruction becomes obvious; for with the Center S, and Radius $ST=m$, deſcribe the Semicircle TDA; and with the ſame Center and Radius $SE=n$, the Semicircle EVB; which two Semicircles ſhall repreſent the Orbs of the *Earth*, and *Venus*. Then make the Chord $AD=$ to the Radius ST, and from D towards A, lay off $DF=SE$; draw TF, and thereon place $FG=BE=2n$, and with the Center T and Radius TG deſcribe the Arch GV, cutting the Semicircle BVE in V; and Fig. 121.

and draw the Lines SV, TV; I ſay the Triangle STV is ſimilar to that, at whoſe Angles are the *Sun*, *Earth*, and *Venus*; at the time when the *Area* of the inlightned Part of that Planet's Diſk, as ſeen from the *Earth*, is greateſt. How this Geometrical Effection follows from the Equation is too evident to need repetition.

In conſequence then of this Solution, I find this *Maximum* always to happen, when the *Planet* is about 40 Degrees diſtant from the *Sun*; and the times thereof, about the middle between her greateſt Elongations on both Sides from him, and her retrograde Conjunctions with him; when little more than a quarter of her viſible Diſk is luminous, and reſembling the Moon of about 5 Days old; and tho' her Diameter is at that time but 50 Seconds, yet ſhe ſhines with ſo ſtrong a Beam, as to ſurpaſs the united Light of all the fixt Stars that appear with her, and caſts a very ſtrong Shade on the Horizontal Plain, whereon they all ſhine: an irrefragable Argument to prove, that the Diſks of the fixt Stars are inconceivably ſmall, and next to nothing; ſince ſhining with a *native* Light, ſo many of them do not equal the *reflex* Light of one quarter of a Diſk of leſs than a Minute Diameter.

In this Situation *Venus* was found in *July* laſt, on the tenth Day; about which time, when the *Sun* grew low, ſhe was very plainly ſeen in the Day time, for ſeveral Days together; as ſhe might have been in the Mornings, about the latter End of *September*. But this, ariſing from the Cauſes we have now ſhewn, is nothing uncommon; for every eighth Year it returns again, ſo that the *Planet* may be ſeen on the ſame Day of the Month and Hour, very nearly in the ſame Place.

Laſtly, It may not be amiſs to note, that the Equation $x = \sqrt{3mm + nn} - 2n$ has a Limit; for if n be equal to $\frac{1}{4}m$, the Point V will fall on B; and the whole Diſk of a Planet at that Diſtance from the *Sun* would be the *Maximum*, *viz.* when in its ſuperiour Conjunction with the Sun. And the like if n were leſs than $\frac{1}{4}m$; the Arch GV in ſuch Caſe not interſecting the Semicircle BE.

XXIX. *The* Occultation *of a* Star *by the* Moon; *and an* Eclipſe *of the* Moon *following it.* Nov. 21. O. S. 1713. *by Mr.* F. Blanchin, n. 340. p. 88.

H. poſt. Merid.			
h.	′	″	
12	53	34	Stella *Bayero* τ Tauri proxime appellit ad limbum Lunæ, obſervata per Teleſcopium duodecim palmarum.
12	54	34	Eadem jam occultata eſt ab ea parte Lunaris limbi, quæ media ferme eſt inter maculas Ariſtarchi & Galilei. Parallelus diurnus à centro Lunæ deſcriptus apparet Auſtralior quam ſtella τ partibus Micrometri $7\frac{1}{2}$, qualium Lunæ Diameter ſubtendit 37. Stellæ igitur τ declinatio Borealior eſt declinatione apparente Lunaris centri minutis circuli maximi $5'\frac{7}{8}$ circiter.
			Sirius attingit Meridianum: unde verificata ſunt tem-
14	0	14	pora.

Stella

h.	′	″	
14	32	57	Stella τ, quæ aliquot minuta exceſſerat è limbo Lunæ, in revolutione diurna præcedit limbum occidentalem Lunæ ſecundis horariis 0′. 33″, eademque præcedit centrum Lunæ ſecundis 103″ ſive 1′. 43″.
14	42	50	Eadem præcedit limbum Lunæ ſecundis 48″, & centrum 1′. 58″.
14	50	37	Differentia Aſcenſionis rectæ ſtellæ & limbi eſt 1′. 03″, centri vero Lunæ & ejuſdem ſtellæ 2′. 13″.
15	0	0	In limbo Lunæ penumbra, quæ antea erat dilutior, ſenſim fit denſior.
15	2	20	Penumbra fit evidentior, ſed nondum apparet Umbra vera.
15	4	20	Initium incidentiæ Lunæ in Umbram veram, ea in parte limbi quæ proxima eſt maculæ *Schiccardi.*
15	5	21	Umbra vera jam obtegit partem unam, qualium Lunæ diameter in Micrometro obtinet 37.
15	7	20	Jam partes duæ obteguntur qualium Lunæ diameter eſt 37.
15	16	20	Jam obteguntur Lunaris diametri $\frac{2}{37}$.
15	31	20	Latent Lunaris diametri $\frac{2}{37}$.
16	12	0	Jam latent in diametro partes $\frac{1}{3}\frac{2}{7}$.
16	17	20	Partes latentes 15 ut antea.
16	50	20	Jam partes latentes $\frac{1}{3}\frac{2}{7}$.
16	54	35	Incipit emergere prior limbus Tychonis.
16	56	9	Jam totus Tycho emergit.
17	13	30	Latent Lunaris diametri partes 5 è 37.
17	27	45	Umbra vera excedit è limbo Lunæ, in loco deſignato per diametrum ductum inter Ariſtarchum & Platonem ſitu inter-medio.

N. B. *Hæc obſervatio pluris æſtimanda, quod occultatio ſtellæ τ acciderit tam vicina Oppoſito ſolis, ut inde locus ſolis inter Fixas rite examinari poterit.*

XXX. Having after Midnight carefully corrected the Clock by no leſs than ten Obſervations of the Altitude of the *Lucida Arietis*, the Error thereof was found 5′. 13″ too faſt, the Extremes not differing above 6″: And in the Morning about 7ʰ, by as many Altitudes of the *Sun*, with a like Agreement, the ſame Error was found 5′. 14″ to be deducted from the Times ſhewn by the Clock.

The Occultation of Jupiter *by the Moon,* July 14. *in the Morning,* 1715, *at* Wanſted, *by Mr.* J. Pound. n.347. p.401.

Julii

Julii 13°. P. M. N.	Time by the Clock.	Time Correct.
	h. ′ ″	h. ′ ″
The third Satellite of *Jupiter* was hid by the Moon	13 27 33	13 22 20
The firſt Satellite was hid	13 32 35	13 27 22
The ſecond Satellite was hid	13 34 25	13 29 11
The firſt Contact of the Limbs of ♃ and ☾	13 34 54	13 29 41
Jupiter wholly hid	13 36 23	13. 31 10
The third Satellite came out from behind the dark Side of the Moon	14 7 25	14 2 12
The firſt Satellite	14 12 25	14 7 12
The ſecond Satellite	14 14 38	14 9 25
The firſt Limb of *Jupiter* came out	14 14 45	14 9 32
The following Limb of ♃ or laſt Contact	14 16 15	14 11 2
The fourth Satellite emerged	14 18 49	14 13 36

Jupiter and the Satellites were to the Northward of the viſible way of the Moon's Center.

This Occultation was obſerved through a Teleſcope, in which the focal Length of the Object-Glaſs was 14 ½ Feet, and of the Eye-Glaſs 2 ¼ Inches. And the Aperture of the Object-Glaſs was 1 $\frac{1}{10}$ Inch.

I could perceive no Colours on *Jupiter*'s Limb, either at his Immerſion or Emerſion, when the Axis of the Tube was directed to him.

The Occultation *of a fixt* Star *in* Gemini *by* Jupiter, *Jan.* 11. O. S. 1717. &c. *by* —— n. 351. p. 546.

XXXI. Ante biennium † indicavimus, *Jovem* corpore ſuo ſtellam quandam fixam obtegere debere, ſignantes diem *Januarii* hujus anni decimum. *Jove* autem pene Stationario, & paulo amplius in Orientem quam per Tabulas noſtras provecto, non ante undecimum incidit prædicta Occultatio; quam quidem *Londini* ob Nubes non contigit ex voto obſervare.

† *Vid.* Supr. p. 298.

Nec fruſtra invigilarunt Aſtronomi noſtri. D. *Martinus Folkes*, *Londini*, præſentibus aliis nonnullis è Societate Regia, *Jan.* undecimo 8ʰ. P. M. vidit *Jovis* centrum una diametro corporis ejus Fixam ſequi, quæ dicto centro Borealior erat quaſi dodrante ſemidiametri Jovis. Poſtea Nubes Jovem occuparunt; habita autem ratione motus Jovis, paulo poſt medium Noctis ſtellam Jovi conjunctam fuiſſe, & a Borea diſci ejus parte occultatam, concluſit.

Reverendus Dominus *J. Theoph. Deſaguliers*, & Dⁿᵘˢ. *Stephanus Grey*, *Weſtmonaſterii*, viderunt Fixam, Horâ ſextâ veſpertinâ, integra Jovis diametro diſtare a limbo ejus, Corum verſus. Unde & ex ſequentium dierum Obſervationibus, circa medium noctis incidiſſe conjunctionem evincitur.

Reverendus

Reverendus quoque D. *J. Pound* apud *Wanſted*, infraſcriptas nactus eſt obſervationes accuratiſſimas Tubo ſcil. prælongo & Micrometro captas.

Januarii Quinto 5^h. 6′. T. æq. Jovis centrum diſtabat a dictâ fixâ 31′ 49″. quam 5^h. 38′. ſequebatur 34′. 12″. Aſcenſionis rectæ: ſimulque limbus *Jovis* auſtrinus eandem habuit Declinationem cum ſtella.

Die autem nono ſequente 6^h. 6′ Jovis Centrum diſtabat a ſtella 10′. 49″; & poſt octo minuta erat differentia Aſcenſionum rectarum 11′. 32″: & tum centrum Planetæ, tantillo ut vix percipi poſſit, erat Stellâ auſtralius.

Die undecimo 5^h. 30′. T. æq. erat diſtantia centrorum 1′. 24″. ſimulque viſa eſt ſtella quaſi quadrante diametri Jovis borealior centro ejus. Diameter autem minima *Jovis* inventa eſt 0′. 43″. Deinde Nubes.

Die vero duodecimo 5^h. 17′. erat diſtantia centrorum 3′. 7″; ac 5^h. 50′. Jupiter ſtellam præcedebat 3′. 30″. Aſcen. Rect. Eodemque tempore limbus Jovis boreus eandem habuit Declinationem quam Fixa accurate.

Collatis autem his Obſervationibus patet Fixam hanc *Jovi* conjunctam *Januarii* undecimo 13^h. circiter, non niſi 17″ vel 18″ centro ejus borealiorem fuiſſe, ac proinde occultatam.

Fixa hæc, etiamſi nulli Catalogo hactenus aſcripta, Locum tunc habuit ♊ 22°. 13′. cum Lat. Auſt. 0°. 13′ ½; Comitemque habet 17 min. eam præcedentem & 7 min. borealiorem, ſive in ♊ 21°. 56′ cum Lat. Auſt. 0°. 6′ ½, cui *Jupiter* conjungi viſus eſt *Jan.* 16. 6^h. 30′. veſperi.

Sic ſpatio minus bimeſtri *Jupiter* corporaliter eclipſavit duas Fixas, cujus rei ne vel unum exemplum ab invento Teleſcopio extat: proinde hæc obſervata inter pretioſiſſima Uraniæ κειμήλια, in uſum Poſterorum, merito reponenda ſunt.

Noſtra autem ſtellula anno 1634. *Feb.* 6. *Jovi* Stationario conjuncta, tribus ejus diametris auſtralior erat, obſervante *Gaſſendo:* unde conſtabit, calculo rite inſtituto, *Jovis* Nodos quoad ſenſum immobiles hæſiſſe, per 83 annos ultimo elapſos, idque ad 2^s. 8°. 35′ a 1^a ✱ ♈.

Ad alteram autem Obſervationem tranſitûs *Martis* prope *Boream Frontis Scorpii* non minus inſignem, iidem Aſtronomi invigilârunt. *Mars* autem, *Februarii* quinto Mane, vel quarto 16^h. viſus eſt adeo vicinus ſtellæ dictæ, ut ea nudis oculis non conſpiceretur; ſed per teleſcopium inventa eſt ſupra & ad ortum, adeoque *Mars* nondum ei conjunctus. Hora 16^h. 10′. T. app. *Mars* erat in recta cum Borea frontis & Teleſcopicâ quæ eam ſequitur ad Boream, ad diſtantiam octo circiter minutorum. 16^h. 35′. *Mars* intermedius erat in recta cum Boreâ & Mediâ Frontis; & poſt horæ quadrantem, cum Auſtrinâ Frontis; ita ut 16^h. 54′ T. app. æſtimabatur Conjunctio ipſa quoad Longitudinem, quo tempore *Mars* ſat accurate duobus tantum minutis auſtralior erat ſtellâ. Obſervavit etiam D. *Pound* Conjunctionem reſpectu Aſcenſionis Rectæ 17^h. 25′. T. app. cum diſtantiâ centrorum 2′. 07″. Jucundum

A Tranſit *of* Mars *below the* Northern Star *in the* Forehead *of* Scorpio, *Feb.* 5. 1717.

autem erat ſpectaculum, *Martem* videre ſtellam pedetentim aggredientem, motumque ſuum, lentiſſimum licet, manifeſte prodentem.

Conferatur cum hac Obſervatio *Horroxii* noſtri anno 1638. *Februarii* Septimo mane, quam vide in Epiſtolis ejus pag. 304. Tunc enim *Mars* ad eandem ſtellam appulſus, etiam multo propius ad eam acceſſit, ſed ante ortum ejus præterierat Conjunctio.

His adde *Saturni* obſervationem *Januarii* 25^to^. 12^h^. 25′. T. æq. à D. *Pound* habitam. Cum Planeta diſtabat à ſtella 58^va^. *Virginis Catal. Brit.* 13′. 16″. verſus Auſtrum, eamque ſequebatur 2′. 30″. Aſc. Rect. Stella in ♎ 19. 21′. 52″. cum lat. Bor. 2°. 47′. 25″.

Emerſions *of the firſt* Satellite *of* Jupiter, *at* Rome, *&c.* 1713. *by Mr.* F. Blanchin, n. 340. p. 89.

XXXII. Sept. $\frac{11}{22}$ poſt meridiem 8^h^. 38′. 20″. Intimus Jovis Satelles incipit emergere, è regione ſpatii inter utramque Jovis faſciam protenſi. Obſervatio peragebatur Teleſcopio D. *Andreæ Chiarelli* longitudinis 40 Palm. Rom. Deinde 8^h^. 44′. Tertius Satelles ita apparebat Quarto conjunctus, ut ambo viderentur unicus Satelles: Diſtabant à centro Jovis diametris Jovialibus circiter $5\frac{1}{2}$. Hora vero 9^h^. 4′. Jam disjuncti videbantur. Quartus ſitu inverſo apparuit paulo depreſſior Tertio, & paulo elongatior a Jove: quare erat Tertio Borealior.

Sept. $\frac{18}{29}$ 10^h^. 36′ 23″. Primus ſeu intimus Satelles incipit emergere ab Umbra, Tubo 25 Palm. Domini *Campani.*

Novemb. $\frac{12}{23}$ 7^h^. 32′. 22″. Primus Satelles incipit emergere, conſpectus per Tubum Domini *Chiarelli* palm. 40. Deinde eadem nocte 7^h^. 46′. Primus & Secundus proximi ſunt, & 7^h^. 53′. iidem ita ſunt vicini ut vix punctulo diſtinguantur.

Decemb. 9. *N. S.* vel Novemb. 28. *V. S.* 5^h^. 45′. 45″. Primus Satelles incipit emergere ab umbra Jovis.

Decemb. 21. *V. S.* 5^h^. 50′ 22″. iterum viſus eſt primus Satelles incipiens emergere ex umbra.

Ex his obſervationibus accurato calculo ſubjectis, manifeſtum eſt æquationem ſecundam, quam a motu Luminis progreſſivo ortam ſupponimus, neceſſario locum habere. Nam poſt 57 *ſatellitis intimi revolutiones, quibus Jupiter a Terra pluſquam Radio Orbis magni receſſit, novem fere minutis tardius conſpecta eſt Eclipſis ultima, quam debuit juxta tenorem Obſervationis primæ: quod quidem Hypotheſibus* D. Caſſini *conſonum eſt.*

Ex iiſdem etiam confirmatur (quod nos quoque antea annotavimus, nempe) *quod motus Intimi Satellitis Jovis paulo celerior ſit quam in Tabulis elaboratiſſimis* D. Caſſini, *ante viginti annos cum publico communicatis. Errorculus autem iſte vix excedere videtur duo temporis minuta in ſingulis Jovis revolutionibus, ſive duodecim annis; quibus cælum anticipat* Caſſini *calculum. Hac vero adhibita correctione, ſatis accuratus habebitur conſenſus.*

XXXIII. On the 16th of *February* 1719. at $6^h \frac{1}{4}$ through a ſhort Tube, we ſaw all the 4 Satellites, the 3 outermoſt on the *Eaſt* Side of *Jupiter*, and the innermoſt near the *Weſtern* Limb approaching to an Eclipſe. The fourth at that time was about half a Semidiameter of *Jupiter* from the Eaſtern Limb. Then it proved cloudy till about 8^h, at which time (through the *Hugenian* Teleſcope) we could ſee only the ſecond and third Satellites, the firſt being behind *Jupiter* in the Shadow, and the fourth entred upon the Diſk. We ſaw at this time a dark Spot, a little *Northward* of the great *Northern* Zone, and near the *Eaſtern* Limb, where the Satellite was to enter on the Diſk; which Spot we took for the Shade of the Satellite. The Clouds then again intercepted our View, till $8^h. 53'$. *Æq. T.* at which time the firſt Satellite was lately emerged out of the Shadow, and the Spot advanced ſo far, that we perceived it would arrive at the middle of *Jupiter*, near two Hours ſooner than the Shade ought to have done by our Computation; but not imagining, that this dark Spot could be any thing elſe but the Shade, we concluded, there had been ſome Error in the Calculation, which we thought to re-examine afterwards. On this Preſumption we left off obſerving till $9^h. 35'$. at which time we were ſurprized to ſee a Notch in the Limb of *Jupiter*, near the Place where the former Spot entred. This laſt Appearance agreeing well with the Time, that the Shade of the Satellite ought to have entred the Diſk, ſoon made us alter our former Opinion, and conjecture, that this, and not the other Spot, was the ſaid Shade. At $9^h. 39' \frac{1}{2}$ *Æq. T.* the Notch vaniſhing, a round black Spot appeared within the Limb, but in contact with it. At $9^h. 45'$. we judged the firſt Spot, and at $11^h. 45'$. the ſecond, to be in the middle of *Jupiter*.

Tranſit *of the Body and Shade of* Jupiter's *fourth* Satellite *over the* Diſk *of the* Planet, *Communicated by Mr.* J. Pound, n. 359. p. 900.

At 11^h 50'. the firſt Spot touched the Limb, being within the Diſk; ſoon after which the Limb in that Place ſeemed a little protuberant. At $12^h. 5'$. appeared the fourth Satellite juſt come out of the Diſk, and touching the Limb in the Place where the Protuberancy was. At $12^h. 7'$. we could perceive the Satellite ſeparated from the Limb. At $13^h. 56'$. the ſecond black Spot, ſtill within the Diſk, juſt touched the *Weſtern* Limb; ſoon after which there appeared a Notch in this Part of the Limb, as it did on the other at the coming on of this Spot. At $14^h. 6'$. the Spot was all gone off, and the Limb appeared clear and entire. The firſt Spot, when in the middle of *Jupiter*, was almoſt as black as the ſecond when near the Limb, but ſomewhat leſs and a little more *Northerly*.

At the time that the firſt Spot was in the middle of the Diſk, the three innermoſt Satellites appeared to the *Eaſt* of *Jupiter*; the firſt (as aforeſaid) having lately emerged out of the Shadow; the ſecond being almoſt at its greateſt Diſtance; and the third having paſſed the Axis of the Shade about twelve Hours before, and appearing at this time about three Diameters of *Jupiter* from his Limb. The

Times that theſe Spots arrived at the middle of the Diſk are agreeable to the Times found by Calculation, in which the fourth Satellite and its Shade ought to have appeared there. From all which 'tis very plain, that the firſt of theſe Spots was the fourth Satellite itſelf, and the ſecond its Shadow.

We have ſeen the firſt and ſecond Satellites appearing not as dark Spots, but as bright ones (ſomewhat different from the Light of *Jupiter*) for ſome little time after they entred his Diſk, but as they approached nearer the middle we loſt Sight of them. And we have frequently obſerved, that the ſame Satellites appear brighter at ſome times than at others; and that when one of them hath ſhined with its utmoſt Splendour, the Light of another hath been conſiderably diminiſhed. From whence 'tis very probable at leaſt, not only that the Satellites revolve upon their proper Axes, but alſo that ſome Parts of their Surfaces do very faintly (if at all) reflect the Solar Rays to us.

All which hath for ſome time ſince been obſerved and taken Notice of by Meſſ. *Caſſini* and *Miraldi*, as may be ſeen in the *Memoirs* of the *Academie Royale*, for the Years 1707 and 1714.

Tables *for computing the* Eclipſes *of the* firſt Satellite *of* Jupiter, *by Mr.* J. Pound, n. 361. p. 1021.

XXXIV. It being now 26 Years ſince Mr. *Caſſini*'s Tables were publiſhed, length of time hath diſcovered, that the Motion of the firſt *Satellite* is a ſmall Matter ſwifter than M. *Caſſini* hath ſuppoſed it; and Mr. *Pound* has of late apply'd himſelf to rectify by frequent Obſervation what he found amiſs in his *Calculus*; and has put it into a Form more eaſy and compendious, by bringing what M. *Caſſini* had given us in odd Numbers, to the Milleſimals of a Circle, both as to *Numb.* I. which he calls *Numb.* A. being the mean Anomalie of *Jupiter* in ſuch Parts; as alſo to *Numb.* II. or our *Numb.* B. which is the Diſtance of the mean Place of *Jupiter*, from the true Place of the *Sun*, and which with the Addition of the Equation of *Numb.* B. gives the true Angle of *Commutation* in the ſame Milleſimals of a Circle. And having deducted from the *Epoches* the greateſt Equations both of *Numb.* A. and B. he reſtores them again by adding as much to the Equations themſelves, by which means they all become affirmative, ſo that the whole Computation is performed by *Addition* only.

† *Vid.* Supr. V. I. C. IV. §. XCII.

In N°. 214 of the *Phil. Tranſ.* † there is an Epitome of Mr. *Caſſini*'s Tables, were the Method of his *Calculus* is explain'd at large, for which Reaſon this ſhorter Deſcription may at preſent ſuffice.

Epoche

Epochæ Conjunctionum primi Satellitis cum Jove.

An. Jul. Curr.	Conjunct. D.	H.	′	″	Num. A.	Num. B.
1719	1	6	11	13	872	396
1720	0	20	22	40	956	310
21	1	5	2	44	40	229
22	0	19	14	11	125	143
23	0	9	25	38	209	57
1724	1	18	5	42	293	971
1725	0	8	17	10	377	889
26	1	16	57	13	462	808
27	1	7	8	41	546	722
28	0	21	20	8	630	636
1729	1	6	0	12	715	554
1730	0	20	11	39	799	468
31	0	10	23	7	883	382
32	0	0	34	34	967	296
33	0	9	14	38	52	215
1734	1	17	54	41	136	133
1735	1	8	6	9	220	47
36	0	22	17	36	305	961
37	1	6	57	40	389	880
38	0	21	9	7	473	794
1739	0	11	20	35	557	708
1740	0	1	32	2	642	622
41	0	10	12	6	726	540
42	0	0	23	33	810	454
43	1	9	3	37	895	373
1744	0	23	15	4	979	287
1745	1	7	55	8	63	205
46	0	22	6	35	148	119
47	0	12	18	3	232	33
48	0	2	29	30	316	947
1749	0	11	9	34	400	866

An. Jul. Curr.	Conjunct. D.	H.	′	″	Num. A.	Num B.
1749	0	11	9	34	400	866
1750	0	1	21	1	485	780
51	1	10	1	5	569	698
52	1	0	12	33	653	612
53	1	8	52	37	738	531
1754	0	23	4	4	822	445
1755	0	13	15	32	906	359
56	0	3	27	0	990	273
57	0	12	7	3	75	191
58	0	2	18	30	159	110
1759	1	10	58	34	243	24
1760	1	1	10	1	328	938
61	1	9	50	35	412	856
62	1	0	1	2	496	770
63	0	14	13	0	580	684
1764	0	4	24	27	665	598
1765	0	13	4	13	749	517
66	0	3	15	58	833	431
67	1	11	56	2	918	349
68	1	2	7	29	2	263
1769	1	10	47	33	86	182
1770	1	0	59	0	171	96
71	0	15	10	28	257	10
72	0	5	21	56	339	924
73	0	14	2	0	423	842
1774	0	4	13	27	508	761
1775	1	12	53	31	592	675
76	1	3	4	58	676	589
77	1	11	45	1	761	507
78	1	1	56	28	845	421
1779	0	16	7	56	929	335

Revolutiones primi Satellitis Jovis in menſibus

Januarii.				N.	Nu.
D.	h.	′	″	A.	B.
1	18	28	36	0	5
3	12	57	12	1	9
5	7	25	48	1	14
7	1	54	24	2	18
8	20	23	0	2	23
10	14	51	36	2	27
12	9	20	12	3	32
14	3	48	48	3	37
15	22	17	24	4	41
17	16	46	0	4	46
19	11	14	36	4	51
21	5	43	12	5	55
23	0	11	47	5	60
24	18	40	23	6	64
26	13	8	59	6	69
28	7	37	35	7	73
30	2	6	11	7	78
31	20	34	47	7	82
Februarii.					
0	20	34	47	7	82
2	15	3	23	8	87
4	9	31	59	8	92
6	4	0	35	9	96
7	22	29	11	9	101
9	16	57	47	9	105
11	11	26	23	10	110
13	5	54	59	10	114
15	0	23	35	11	118
16	18	52	11	11	123
18	13	20	47	11	128
20	7	49	23	12	132
22	2	17	59	12	137
23	20	46	35	13	141
25	15	15	11	13	146
27	9	43	47	13	150

Martii.				N.	Nu.
D.	h.	′	″	A.	B.
1	4	12	23	14	155
2	22	40	59	14	159
4	17	9	35	15	164
6	11	38	10	15	168
8	6	6	46	16	173
10	0	35	22	16	177
11	19	3	58	16	182
13	13	32	34	17	186
15	8	1	10	17	190
17	2	29	46	18	195
18	20	58	22	18	199
20	15	36	58	18	204
22	9	55	34	19	208
24	4	24	10	19	213
25	22	52	46	20	217
27	17	21	22	20	221
29	11	49	58	20	225
31	6	18	34	21	230
Aprilis.					
0	6	8	34	21	230
2	0	47	10	21	235
3	19	15	46	22	239
5	13	44	22	22	244
7	8	12	58	22	248
9	2	41	34	23	252
10	21	10	10	23	257
12	15	38	46	24	261
14	10	7	22	24	265
16	4	35	58	25	270
17	23	4	33	25	274
19	17	33		25	279
21	12	1	45	26	283
23	6	30	21	26	287
25	0	58	57	27	292
26	19	27	33	27	296

Revolutiones primi Satellitis Jovis in menſibus

Aprilis.				N.	Nu.
D.	h.	′	″	A.	B.
28	13	56	9	27	300
30	8	24	45	28	304
Maii.					
0	8	24	45	28	304
2	2	53	21	28	309
3	21	21	57	29	313
5	15	15	33	29	317
7	10	90	9	29	322
9	4	47	45	30	326
10	23	16	21	30	330
12	17	44	57	31	335
14	12	13	33	31	339
16	6	42	9	31	343
18	1	10	45	32	348
19	19	39	21	32	352
21	14	7	57	33	356
23	8	36	33	33	361
25	3	5	9	33	365
26	21	33	45	34	369
28	16	2	21	34	373
30	10	30	57	35	378
Junii.					
0	10	30	57	35	378
1	4	59	32	35	382
2	23	28	8	36	386
4	17	56	44	36	391
6	12	25	20	36	395
8	6	53	56	27	399
10	1	22	32	37	403
11	19	51	8	38	408
13	14	19	44	38	412
15	8	48	20	38	416
17	3	16	56	39	420
18	21	45	32	39	425
20	16	14	8	40	429
22	10	42	44	40	433

Junii.				N.	Nu.
D.	h.	′	″	A.	B.
24	5	11	20	40	438
25	23	39	56	41	442
27	18	8	32	41	446
29	12	37	8	42	450
Julii.					
1	7	5	44	42	455
3	1	34	20	42	459
4	20	2	56	43	463
6	14	31	32	43	468
8	9	0	8	44	472
10	3	28	44	44	476
11	21	57	20	45	480
13	16	25	55	45	485
15	10	54	31	45	489
17	5	23	7	46	493
18	23	51	43	46	498
20	18	20	19	47	502
22	12	48	55	47	506
24	7	17	31	47	510
26	1	46	7	48	515
27	20	14	43	48	519
28	14	43	19	49	523
31	9	11	55	49	528
Auguſti.					
0	9	11	55	49	528
2	3	40	31	49	532
3	22	9	7	50	536
5	16	37	43	50	541
7	11	6	19	51	545
9	5	34	55	51	549
11	0	3	31	51	554
12	18	32	7	52	558
14	13	0	43	52	562
16	7	29	19	53	567
18	1	57	55	53	571
19	20	26	31	54	575

Revolutiones primi Satellitis Jovis in menſibus

Auguſti.				N.	Nu.
D.	h.	′	″	A.	B.
21	14	55	7	54	580
23	9	23	43	54	584
25	3	52	18	55	588
26	22	20	54	55	593
28	16	49	30	56	597
30	11	18	6	56	602
Septembris.					
1	5	46	42	56	606
3	0	15	18	57	610
4	18	43	54	57	615
6	13	12	30	58	619
8	7	41	6	58	624
10	2	9	42	58	628
11	20	38	18	59	632
13	15	6	54	59	637
15	9	35	30	60	641
17	4	4	6	60	646
18	22	32	42	60	650
20	17	1	18	61	655
22	11	29	54	61	659
24	5	58	30	62	663
26	0	27	6	62	668
27	18	55	42	62	672
29	13	24	18	63	677
Octobris.					
1	7	52	54	63	681
3	2	21	30	64	686
4	20	50	6	64	590
6	15	18	41	65	595
8	9	47	17	65	699
10	4	15	53	65	704
11	22	44	29	66	708
13	17	13	5	66	713
15	11	41	41	67	717
17	6	10	17	67	721
19	0	38	53	67	726
20	19	7	29	68	730
22	13	36	5	68	735
24	8	4	41	69	739
26	2	33	17	69	744
27	21	1		69	749
29	15	30	29	70	753

Octobris.				N.	Nu.
D.	h.	′	″	A.	B.
31	9	59	5	79	758
Novembris.					
0	9	59	5	70	758
2	4	27	41	71	762
3	22	56	17	71	767
5	17	24	53	71	772
7	11	53	29	72	776
9	6	22	5	72	781
11	0	50	41	73	785
12	19	19	17	73	790
14	13	47	53	74	794
16	8	16	29	74	799
18	2	42	5	74	804
19	21	13	40	75	808
21	15	42	16	75	813
23	10	10	52	76	817
25	4	39	28	76	822
26	23	8	4	76	827
28	17	36	40	77	831
30	12	5	16	77	836
Decembris.					
0	12	5	16	77	836
2	6	33	52	78	840
4	1	2	28	78	845
5	19	31	4	78	849
7	13	59	40	79	854
9	8	28	16	79	859
11	2	56	52	80	863
13	21	25	28	80	868
14	15	54	4	80	873
16	10	22	40	81	877
18	4	51	16	81	882
19	23	19	52	82	886
21	17	48	28	82	891
23	12	17	4	82	897
25	6	45	40	83	900
27	1	14	16	83	905
28	19	42	52	84	909
30	14	11	28	84	914

Primæ Æquationes Conjunctionum primi Satellitis cum Jove.

Num. A.	Æquat. Conjunct. Adde.	Æq Nu. B.	Num. A.	Æquat. Conjunct. Adde.	Æq Nu B	Num. A.	Æquat. Conjunct. Adde.	Æq Nu. B	Num A.	Æquat. Conjunct. Adde.	Æq Nu. B
	′ ″			′ ″			′ ″			′ ″	
0	39 8	15	128	12 7	26	256	0 1	31	384	11 52	26
4	38 12	16	132	11 27	26	260	0 0	31	388	12 37	26
8	37 16	16	136	10 47	26	264	0 1	31	392	13 23	25
12	36 21	16	140	10 9	27	268	0 3	31	396	14 11	25
16	35 26	17	144	9 31	27	272	0 7	31	400	14 59	25
20	34 30	17	148	8 45	27	276	0 12	31	404	15 48	24
24	33 35	17	152	8 19	27	280	0 19	31	408	16 38	24
28	32 40	18	156	7 44	28	284	0 28	30	412	17 30	24
32	31 45	18	160	7 10	28	288	0 38	30	416	18 22	23
36	30 50	19	164	6 38	28	292	0 50	30	420	19 15	23
40	29 56	19	168	6 7	28	296	1 3	30	424	20 9	23
44	29 3	19	172	5 37	28	300	1 17	30	428	21 4	22
48	28 10	20	176	5 8	29	304	1 33	30	432	22 59	22
52	27 16	20	180	4 41	29	308	1 50	30	436	22 55	22
56	26 23	20	184	4 15	29	312	2 8	30	440	23 53	21
60	25 30	21	188	3 49	29	316	2 28	30	444	24 51	21
64	24 38	21	192	3 24	29	320	2 51	30	448	25 49	21
68	23 47	21	196	3 1	29	324	3 15	29	452	26 48	20
72	22 56	22	200	2 40	30	328	3 40	29	456	27 48	20
76	22 5	22	204	2 20	30	332	4 6	29	460	28 48	19
80	21 15	22	208	2 1	30	336	4 34	29	464	29 49	19
84	20 26	23	212	1 42	30	340	5 3	29	468	30 50	19
88	19 37	23	216	1 25	30	344	5 34	29	472	31 51	18
92	18 48	23	220	1 10	30	348	6 5	28	476	32 53	18
96	18 0	24	224	0 58	30	352	6 38	28	480	33 55	17
100	17 14	24	228	0 47	30	356	7 13	28	484	34 57	17
104	16 28	24	232	0 36	30	360	7 50	28	488	35 59	17
108	15 42	24	236	0 26	30	364	8 27	27	492	37 1	16
112	14 57	25	240	0 18	30	368	9 6	27	496	38 5	16
116	14 13	25	244	0 12	31	372	9 46	27	500	39 8	15
120	13 30	25	248	0 7	31	376	10 27	27	504	40 11	15
124	12 48	26	252	0 4	31	380	11 9	26	508	41 15	14
128	12 7	26	256	0 1	31	384	11 52	26	512	42 17	14

Primæ Æquationes Conjunctionum primi Satellitis cum Jove.

Num A	Æquat. Conjunct. Adde.	Æq Nu. B	Num. A.	Æquat. Conjunct Adde.	Æq Nu B.	Num. A.	Æquat. Conjunct. Adde.	Æq Nu. B.	Num. A.	Æquat. Conjunct Adde.	Æq Nu. B.
	′ ″			′ ″			′ ″			′ ″	
512	42 17	14	640	70 26	3	768	77 40	0	896	61 48	6
516	43 19	14	644	71 3	3	772	77 29	0	900	61 2	7
520	44 21	13	648	71 38	3	776	77 18	0	904	60 15	7
524	45 23	13	652	72 11	2	780	77 6	0	908	59 28	7
528	46 25	13	656	72 42	2	784	76 51	1	912	58 39	8
532	47 26	12	660	73 13	2	788	76 34	1	916	57 50	8
536	48 27	12	664	73 42	2	792	76 15	1	920	57 1	8
540	49 28	11	668	74 10	2	796	75 56	1	924	56 11	9
544	50 28	11	672	74 36	1	800	75 36	1	928	55 20	9
548	51 28	11	676	75 1	1	804	75 15	1	932	54 29	9
552	52 27	10	680	75 25	1	808	74 52	1	936	53 38	10
556	53 25	10	684	75 48	1	812	74 27	1	940	52 46	10
560	54 23	9	688	76 8	1	816	74 1	2	944	51 53	10
564	55 21	9	692	76 26	1	820	73 35	2	948	51 0	11
568	56 17	9	696	76 43	0	824	73 8	2	952	50 6	11
572	57 12	8	700	76 59	0	828	72 39	2	956	49 13	11
576	58 7	8	704	77 13	0	832	72 9	2	960	48 20	12
580	59 1	8	708	77 26	0	836	71 38	3	964	47 26	12
584	59 54	7	712	77 38	0	840	71 6	3	968	46 31	12
588	60 46	7	716	77 48	0	844	70 32	3	972	45 36	13
592	61 38	6	720	77 57	0	848	69 57	3	976	44 41	13
596	62 28	6	724	78 4	0	852	69 21	3	980	43 46	13
600	63 17	6	728	78 9	0	856	68 45	4	984	42 50	14
604	64 5	5	732	78 13	0	860	68 7	4	988	41 55	14
608	64 53	5	736	78 15	0	864	67 29	4	992	41 0	14
612	65 39	5	740	78 16	0	868	66 49	4	996	40 4	15
616	66 24	5	744	78 15	0	872	66 9	5	1000	39 8	15
520	67 7	4	748	78 12	0	876	65 28	5	1004	38 12	16
524	67 49	4	752	78 9	0	880	64 46	5	1008	37 16	16
28	68 30	4	756	78 4	0	884	64 3	5	1012	36 21	16
632	69 10	4	760	77 58	0	888	63 19	6	1016	35 26	17
636	69 49	3	764	77 50	0	892	62 34	6	1020	34 30	17
640	70 26	3	768	77 40	0	896	61 48	6	1024	33 35	17

Secundæ Æquationes Conjunctionum primi Satellitis cum Jove.

Addendæ.

Num. B. Æqu.	0	100	200	300	400	500	600	700	800	900
	Æqu.	*Æqu.*	*Æq.*	*Æq.*	*Æq.*	*Æq.*	*Æq.*	*Æq.*	*Æqu.*	*Æqu.*
	′ ″	′ ″	′ ″	′ ″	″ ′	′ ″	′ ″	′ ″	′ ″	′ ″
0	14 0	12 52	9 45	5 30	1 37	0 0	1 37	5 30	9 45	12 52
4	14 0	12 46	9 36	5 20	1 30	0 0	1 44	5 40	9 54	12 58
8	13 59	12 40	9 26	5 9	1 23	0 1	1 52	5 51	10 3	13 2
12	13 59	12 35	9 17	4 59	1 16	0 2	1 59	6 1	10 12	13 7
16	13 58	12 29	9 7	4 48	1 9	0 3	2 7	6 11	10 21	13 11
20	13 57	12 23	8 58	4 38	1 3	0 4	2 15	6 22	10 31	13 16
24	13 56	12 17	8 48	4 28	0 57	0 5	2 24	6 33	10 40	13 20
28	13 54	12 11	8 38	4 18	0 52	0 7	2 32	6 44	10 49	13 25
32	13 53	12 4	8 28	4 8	0 46	0 10	2 41	6 55	10 57	13 29
36	13 51	11 56	8 17	3 58	0 40	0 13	2 50	7 5	11 5	13 33
40	13 49	11 49	8 7	3 58	0 35	0 16	2 59	7 16	11 13	13 36
44	13 47	11 42	7 57	3 38	0 31	0 19	3 9	7 26	11 20	13 38
48	13 44	11 34	7 47	3 29	0 27	0 23	3 19	7 36	11 27	13 41
52	13 41	11 27	7 36	3 19	0 23	0 27	3 29	7 47	11 34	13 44
56	13 38	11 20	7 26	3 9	0 19	0 31	3 38	7 57	11 42	13 47
60	13 36	11 13	7 16	2 59	0 16	0 35	3 48	8 7	11 49	13 49
64	13 33	11 5	7 5	2 50	0 13	0 40	3 58	8 17	11 56	13 51
68	13 29	10 57	6 55	2 41	0 10	0 46	4 8	8 28	12 4	13 53
72	13 25	10 49	6 44	2 32	0 7	0 52	4 18	8 38	12 11	13 54
76	13 20	10 40	6 33	2 24	0 5	0 57	4 28	8 48	12 17	13 56
80	13 16	10 31	6 22	2 15	0 4	1 3	4 38	8 58	12 23	13 57
84	13 21	10 21	6 11	2 7	0 3	1 9	4 48	9 7	12 29	13 58
88	13 7	10 12	6 1	1 59	0 2	1 16	4 59	9 17	12 35	13 59
92	13 2	10 3	5 51	1 52	0 1	1 23	5 9	9 26	12 40	13 59
96	12 58	9 54	5 40	1 44	0 0	1 30	5 20	9 36	12 46	14 0
100	12 52	9 45	5 30	1 37	0 0	1 37	5 30	9 45	12 52	14 0

Tertiæ Æquationes Addendæ.			*Semidurationes Eclipsium primi Satellitis Jovis.*											
Nu. A.	*Æquationes.*	*Nu. A.*	*Nu. A.*	*Semidurationes* H. ′ ″	*Nu. A.*	*Semidurationes.* H. ′ ″	*Nu. A.*	*Semidurationes.* H. ′ ″	*Nu. A.*	*Semidurationes.* H. ′ ″
0	3 30	1000	0	1 5 9	250	1 7 0	500	1 5 9	750	1 7 46
20	3 29	980	10	1 4 56	260	1 7 15	510	1 4 53	760	1 7 57
40	3 28	960	20	1 4 44	270	1 7 31	520	1 4 39	770	1 8 7
60	3 25	940	30	1 4 33	280	1 7 45	530	1 4 26	780	1 8 15
80	3 19	920	40	1 4 23	290	1 7 57	540	1 4 15	790	1 8 22
100	3 12	900	50	1 4 13	300	1 8 7	550	1 4 7	800	1 8 26
120	3 4	880	60	1 4 7	310	1 8 15	560	1 4 3	810	1 8 28
140	2 56	860	70	1 4 4	320	1 8 22	570	1 4 1	820	1 8 30
160	2 46	840	80	1 4 2	330	1 8 27	580	1 4 0	830	1 8 28
180	2 34	820	90	1 4 0	340	1 8 28	590	1 4 3	840	1 8 26
200	2 22	800	100	1 4 2	350	1 8 29	600	1 4 7	850	1 8 22
220	2 10	780	110	1 4 3	360	1 8 27	610	1 4 13	860	1 8 16
240	1 57	760	120	1 4 6	370	1 8 24	620	1 4 23	870	1 8 8
260	1 44	740	130	1 4 12	380	1 8 17	630	1 4 35	880	1 8 0
280	1 30	720	140	1 4 21	390	1 8 9	640	1 4 49	890	1 7 50
300	1 17	700	150	1 4 31	400	1 7 58	650	1 5 4	900	1 7 37
320	1 5	680	160	1 4 42	410	1 7 46	660	1 5 19	910	1 7 22
340	0 53	660	170	1 4 55	420	1 7 31	670	1 5 36	920	1 7 8
360	0 41	640	180	1 5 9	430	1 7 14	680	1 5 54	930	1 6 55
380	0 31	620	190	1 5 23	440	1 6 58	690	1 6 10	940	1 6 40
400	0 22	600	200	1 5 39	450	1 6 40	700	1 6 28	950	1 6 23
420	0 14	580	210	1 5 55	460	1 6 20	710	1 6 46	960	1 6 8
440	0 8	560	220	1 6 11	470	1 6 2	720	1 7 2	970	1 5 54
460	0 4	540	230	1 6 26	480	1 5 45	730	1 7 17	980	1 5 37
480	0 2	520	240	1 6 43	490	1 5 26	740	1 7 33	990	1 5 22
500	0 0	500	250	1 7 0	500	1 5 9	750	1 7 46	1000	1 5 9

The Uſe *of the* Tables.

The Eclipſes of the *firſt* Satellite of *Jupiter* afford the beſt Means of determining the Longitude of Places on the Land, where Teleſcopes of a convenient Length may be uſed; thirteen of theſe Eclipſes happening every 23 Days; and that the Obſerver may know near the Matter, when theſe Opportunities offer themſelves, he may readily compute the Times of the Immerſions or Emerſions of this Satellite with great Exactneſs, by following very ſhort Precepts, which admit of no Exception or Caution, *viz.*

Out of the firſt Table take the *Epoche* for the Year, with its correſponding *Numb.* A and *Numb.* B; and to them add out of the Tables of Months, the Day, Hour, Minute and Second, neareſt leſs than the Time of the Eclipſe you ſeek for, together with its *Numb.* A and B: the Sum of the Times is the mean Time of the Middle of the Eclipſe. 2. With *Numb.* A thus collected take out the firſt Æquation of the Conjunctions; as alſo the Æquation of *Numb.* B always to be added to *Numb.* B before found. 3. With *Numb.* B ſo equated, take out the ſecond Æquation of the Conjunctions; and in the laſt Table, the third Æquation, as alſo the Semi-duration of the Eclipſe anſwering to *Numb.* A. 4. To the mean Time of the Middle of the Eclipſe, add all thoſe three Æquations; the Sum ſhall be the true equated Time of the Middle of the Eclipſe ſought. 5. If *Numb.* B equated be leſs than 500, ſubtract the Semiduration, and you will have the Time of the Immerſion, or if it be more than 500, adding the ſame, it will give the Time of the Emerſion.

But Note, the Times thus found are equal time, ſtill to be reduced to the Apparent: And that in the *Biſſextile* Year, after *February*, one Day is to be deducted from the Day of the Month.

Let it be required to find the Time of the *Immerſion* of this Satellite into *Jupiter*'s Shadow, *November* the 9th 1719. in the Morning. The Work ſtands thus,

	D.	h.	′	″	Nu. A.	Nu. B.	
1719.	1 .	6 .	11 .	13	872	396	
Novemb.	7 .	11 .	53 .	29	72	776	
Conj. Med.	8 .	18 .	4 .	42	944	172	
Æquat. I.			51 .	53		10	Æq. B.
Æquat. II.			10 .	26			
Æquat. III.			3 .	26		182	B. Æquat.
	8 .	19 .	10 .	27			
		1 .	6 .	33	*Semidur. Subſt.*		
Novemb.	8 :	18 .	3 .	54			

So

So that by this *Calculus*, on the ninth of *Novemb.* at four Minutes after ſix in the Morning, equal Time, may be ſeen the *Immerſion* of this Satellite into *Jupiter*'s Shadow.

Another Example ſhall be of the *Emerſion* on the fifth of *April* 1720. *viz.*

	D.	h.	′	″		N. A.	Nu. B.	
1720	0	20	22	40		956	310	
April	4	13	44	22	Biſs.	22	244	
Conj. Med.	5.	10	07	02		978	554	
Æquat. I.			44	13			13	Æq. B.
Æquat. II.			0	45				
Æquat. III.			3	29			567	B. Æquat.
		1	5	40	*Semidur. Add.*			
April	5	12	01	09				

Hence it appears, that at one Minute after Midnight following the fifth of *April*, equal Time, will happen the Emerſion required.

It may not be amiſs to inform the Reader, that we have learnt, by the Experience of many Years Obſervation, that the ſecond Inequality of this Satellite proceeds from the progreſſive Propagation of Light, and is common to all the reſt of the Satellites: Light being found to proceed, in about ſeven Minutes of Time, as far as from the Sun to the Earth, whether with an equable Motion or otherwiſe is ſtill a Queſtion. For this Reaſon we have added a *third Equation*, whereby to account for the greater Diſtance of *Jupiter* from the *Earth* in *Aphelio* than in *Perihelio*, as the *ſecond Æquation* anſwers to the greater Diſtance of the Planet, when near the Conjunction of the Sun, than when near his Oppoſition.

Obſervations *on ſome of the primary* Planets; *and the* Occultation *of a* fixt Star, *by* Jupiter, *by Mr.* J. Pound, n. 350. p. 506.

XXXV. Obſervationes ſequentes nemini arte vel induſtria ſecundus Rev. D. *Pound* à ſe nuper apud *Wanſted* habitas, Tubiſque longiſſimis & Micrometro quantum fieri potuit accuratè captas, cum publico communicandas obtulit.

Anno 1715. *Auguſti* 21°. 8ʰ. 25′½ Temp. æq. *Mars* præcedebat, ſcil. Aſcenſione rectâ, Mediam frontis Scorpii (*Bayero* δ) 6′. 54″ borealior Fixâ 9′. 47″.

Sept. 18°. 7ʰ. 30′. *Mars* præcedebat Claram in pede Serpentarii (*Bayero* ϵ) 17′. 48″. & eandem habuit Declinationem accuratè.

Novemb. 30. 18ʰ. 8′. *Suturnus* præcedebat γ, ſive ſecundam Alæ Virginis 23′. 19″ & erat Fixâ auſtralior 25′. 3″. *Decembris* autem 4ᵗᵒ. 17ʰ. 25′. præcedebat eam 10′. 50″ & auſtralior erat 29′. 00″.

Anno

Anno autem 1716. *Feb.* 22°. 7ʰ. 23′ T. æq. *Mars* præcedebat ζ Piſcium, ſive Sequentem trium clariorum in Lino auſt. Piſcium 3′. 35″ eâdemque auſtralior erat 1′. 23″, quam proinde obtegere debuit ante bihorium, forſan corporaliter.

Junii 22°. 8ʰ. 52′ T. æq *Venus* ſequebatur Cor Leonis 34′. 50″, & Fixâ auſtralior erat 7′. 23″.

Aug. 14°. 15ʰ. 00′. *Jupiter* præcedebat *Propoda* uno tantum minuto, cum Declinatione bor. minore 14′. 26″.

Aug. 19°. 13ʰ. 2′ *Jupiter* præcedebat fixam Teleſcopicam, quæ vocetur *b*, 50′. 08″ eandem habens Declinationem accuratè.

Aug. 24°. 12ʰ. 19′ *Jupiter* Micrometro diſtabat a prædictâ *b*, 5′. 54″. ſimulque ab aliâ Fixâ clariore *a* 7′. 17″. Diſtantia fixarum 12′. 31″. Tunc minor *Jovis* diameter 0′ 38″.

Sept. 12°. 17ʰ. 00 *Venus* recens a Statione ſecunda ſequebatur Teleſcopicam 17′. 40″, eâque auſtralior erat 5′. 30″. Hæc autem Fixa tunc occupavit ♌ 27°. 44′½ cum Lat. auſt. 5°. 39.

Octob. 15°. 17ʰ. 12′½ *Venus* diſtabat Microm. a Fixâ τ in Crure Leonis 27′. 55″.

Novemb. 20°. 6ʰ. 18′½ *Jupiter* regreſſus eſt ad ſtellas *a* & *b*, ad quas obſervatus eſt *Aug.* 24°. & diſtabat à *b* 6′. 21″, ab *a* vero 11′. 36″.

Novemb. 21. 7ʰ. 38′, *Jupiter* diſtabat à *b* 9′. 19″, & ab *a* 3′. 48″. Fixæ inter ſe 12′. 30″. *Jovis* diameter minor ſive Axis 0′. 44″. Deinde hora 18ʰ. 50′. viſa eſt ſtella *a* limbo *Jovis* quaſi adhærere, eratque quaſi ⅔ ſemidiametri vel 0′. 15″. centro *Jovis* borealior. Juxta has autem Obſervationes conſtat medium Occultationis Fixæ, interpoſito *Jovis* corpore, contigiſſe *Nov.* 21°. 19ʰ. 55′. vel proximè. Deinde

Nov.	30.	5ʰ.	41′	♃	præced. *Propoda*	12′. 36″	*Auſtralior*	7′. 36″
Dec.	4.	6.	0	♃	Sequeb. eam —	22. 49	———	7. 47
Dec.	5.	6.	0		Repet. ———	31. 35	———	7. 50
Dec.	6	6.	0		Repet. ———	40. 30	———	7. 52
Dec.	7.	6.	0		Iterum ———	49. 15	———	7. 54

Ex his ultimis Obſervationibus liquet *Jovem* & *Propoda* eandem habuiſſe Longitudinem *Dec.* 1°. 15ʰ. 29′, quo tempore *Jupiter* auſtralior erat ſtella 7′ 40″. Ex iiſdem etiam conſtabit *Jovem* in oppoſito Solis fuiſſe, quoad Aſcenſionem rectam *Dec.* 6ᵗᵒ. 12ʰ. 46′. quoad Longitudinem vero *Dec.* 6ᵗᵒ. 12ʰ. 34′½.

N. B. Stellas illas Teleſcopicas *a* & *b* vocatas, haberi in Catalogo Fixarum Britannico D. *Flamſteedii*, ubi ipſi *a* Locus datur, ad annum ſcil. 1690 ineuntem, ♊ 27°. 54′. 29″ cum Lat. auſt. 0 21′. 55″; alteri vero *b* ♊ 28°. 5′. 24″ cum Lat. auſt. 28′. 5″. Neque aliam novimus Fixam à corpore *Jovis* occultatam, & ab invento Teleſcopio obſervatam, præter jam dictam Stellam *a*; ad quam olim arctiſſime applicabatur *Jupiter*, ante annos 83. *Decembris* nono St. nov. Anni 1633. Veſp. cum *Gaſſendus Diniæ* vidit *Jovem* huic Fixæ conjunctum, nec niſi quinque ſemidiametris corporis ſui ſuperiorem. Unde calculo

culo debitè inito, conſtabit Nodos hujus Planetæ, Planumque Orbis ejus, ſitum in Sphæra Fixarum ſervare immobilem, vel ſaltem lentiſſimo motu cieri. Vide *Gaſſendi* Obſerv. Tom. IV. p. 162.

Rectification *of the* Motions *of the five* Satellites *of* Saturn; *with* Obſervations *by Mr.* J. Pound, n. 355. p. 768.

XXXVI. Mr. *Caſſini* above 30 Years communicated to the World his Diſcovery of the two new *Satellites* of *Saturn*, which made their Number Five. Much about the ſame time Mr. *Huygens* made the Society a Preſent of the Glaſſes of a *Teleſcope* of 125 Foot length, with the *Apparatus* for uſing them without a Tube; by Help whereof we might have ſatisfied ourſelves of the Reality of theſe Diſcoveries. But thoſe here, that firſt tried to make uſe of this Glaſs, finding, for want of Practice, ſome Difficulties in the Management thereof, were the Occaſion of its being laid aſide for ſome time.

In the mean time the *French* Aſtronomers, giving us in their Yearly *Memoirs* no Obſervations of theſe *Satellites* till very lately, nor having ſeem'd willing to ſhew them in their Glaſſes to ſuch as requeſted it, occaſioned in ſome Perſons a Suſpicion of the reality of this Diſcovery: And Mr. *Derham* having borrowed of the Society their long Glaſs, could not thereby aſſure himſelf, that the ſmall Stars he ſometimes found about *Saturn*, were really his Satellites, their Situation not agreeing with their Places derived from the Tables of their Motions exhibited in N° 187. † of *Phil. Tranſact.* beſides that he wanted a ſufficient Height to raiſe the Object Glaſs, ſo as to view *Saturn* to Advantage, above the Vapour of the Horizon. But in the *Memoirs* for 1714. M. *Caſſini*, the worthy Succeſſor of his great Father, has given us ſome Obſervations, which clear up the Point, and by ſhewing the Errors of thoſe firſt Tables, has enabled us to be aſſured, that we have ſeen the whole *Satellitium* of *Saturn* ourſelves.

Vid. Supr. V. I. C. IV. S. LXXXII.

The Subſtance of theſe Obſervations is as follows.

Anno 1714, *Maii* 6 *St. N.* about Mid-night, *Saturn* being then Stationary in ♍ 4°. 27′, the fifth and outermoſt Satellite was in its ſuperior Conjunction with the Planet, and at the ſame time, the Earth was nearly in the Plain of this Satellite's Orbit, ſo that it appeared to paſs very near the Center of *Saturn:* From hence, and from ſome other preceding Obſervations, Mr. *Caſſini* concludes, that the Nodes of this Satellite's Orb are in 4 Degrees of ♍ and ♓, and that its Inclination to the Ecliptick is not much more than half that of the other Satellites. Hence it ſhould follow that the Ellipſes it deſcribes by its apparent Motion about *Saturn*, when in ♊ and ♐ are much flatter and nearer to his Body, than thoſe of the other four, which he allows to move in the Plain of the *Ring*, and to have their Nodes in 21 gr. of ♍ and ♓, with an Inclination to the Ecliptick of 31 Degrees. To confirm this Diſcovery, he produces another Obſervation of his Father's, near thirty Years before, *viz.* that *Anno* 1685, *Maii* 31. *St. N.* about Noon, the ſame Satellite was obſerved in ſuperiour Conjunction with *Saturn*, with leſs than one Diameter of the Ring *North* Latitude,

titude, *Saturn* being then in ♍ 11°. 48′. So that the Satellite wanted but 7°. 21′ of completing 134 Revolutions, in the Interval of time between them. From theſe *Data* it was eaſy to ſettle the Theory of this Satellite.

As to the *Fourth*, or the *Hugenian* Satellite; in the *Memoirs* for 1715, we find a very curious Obſervation of it, and the firſt of its kind, *viz.* that *Mart.* 25°. *S. N.* about 11ʰ *P. M.* this fourth Satellite, then in *Apogeo*, did immerge behind the Body of *Saturn*. With this Emendation the Place of this Satellite may for the future be computed with a ſufficient exactneſs.

The third Satellite, by an original Miſtake in the Letters in N°. 187, † is all wrong; its daily Motion being there printed 2ˢ. 18°. 41′. 50″ inſtead of 2ˢ. 19°. 41′. 50″; as may be perceived by the Period thereof being determined in the aforeſaid *Memoirs* of 1714, to be 4ᵈ. 19ʰ. 25′. 12″. that is, that it makes 400 Revolutions in 1807 Days. This Satellite was obſerved by Mr. *Caſſini*, *April* 4ᵗᵒ *St. N.* 10ʰ. *P. M.* to have newly paſt its inferior Conjunction with *Saturn*, and a Perpendicular from it fell on the Extremity of the Weſtern *Anſe*, ſo that at about 5ʰ. *P. M.* it was with the Center of the Planet then in ♍. 5°. 23′. and conſequently in ♓ 5°. 23′. But *ineunte anno Gregoriano* 1686, the *Epoche* thereof was ♍ 9°. 39′. So that from the Noon of the laſt of *December* 1685, to *April* 4°. 6ʰ. 18′. *anno* 1714, that is, in 10320 Days 6ʰ. 18′, there have been made 2284½ Revolutions of this Satellite to the Equinoctial; from which *Data*, the Tables of its Motion are readily derivable.

† *Vid.* Supra V. I. C. IV. S. LXXXII.

The Radix of the Penintime or ſecond Satellite, according to the aforeſaid Letter, *ineunte anno Gregoriano* 1686. was in ♍ 9°. 10′. But by the Obſervations of Mr. *Caſſini* made the Nights before and after, this Satellite was in its ſuperior Conjunction *anno* 1714. *April* 4ᵈ. 21′½. *St. N.* that is, in ♍ 5°. 21′, where *Saturn* then was: So that *April* 4ᵈ. 22ʰ. 12′, an entire Number of Revolutions were performed ſince the *Epoche* of 1686, that is, in 10320 Days 22ʰ. 12′: Which Number can be no other than 3771, according to the Period thereof given in this *Memoire*, *viz.* 2ᵈ. 17ʰ. 41′. 22″.

Laſtly, The innermoſt or firſt Satellite, at the ſame time, *viz.* 1714, *April* 4°. 21ʰ. 30′. *St. N.* was in its inferior Conjunction *proxime*, and conſequently in ♓ 5° 21′. But the *Epoche* thereof for 1686, is ♈. 24°. 50′. which Place the Satellite had paſt 40 gr. 31′ at the time of the Obſervation. This Arch it moves in 5ʰ. 6′: Wherefore from the time of the *Epoche* to *April* 4ᵈ. 16ʰ. 24′, 1714, or in 10320 Days 16ʰ. 24′. the Satellite has performed 5467 Revolutions, its Period being determined to be 1 Day, 21 Hours, 18′. 27″, in this *Memoire*.

Having by the Help of theſe late Obſervations corrected the Motions of the Satellites, and having fixed their *Epoches* for the preſent Year, we were enabled to know where to expect them with more Certainty, and to diſtinguiſh them one from another, and from the ſmall fixt Stars

appearing with them. And Mr. *J. Pound* having, by Means of his Steeple of *Wanſted*, provided a *Gnomon* high enough for the Purpoſe, and having fitted a very commodious *Apparatus* for uſing the *Society*'s aforeſaid long Teleſcope, ſoon diſcovered by it all theſe five Satellites; and lately communicated to them the following Obſervations.

1718. *April* 21^{d}. 10^{h}. 40′. The third and fourth Satellites of *Saturn* were in *Apogæo*, a little paſt their Conjunction with *Saturn:* A Perpendicular from the fourth to the tranſverſe *Axis* of the Ring (or Line of the *Anſæ*) fell a little without the Eaſtern *Anſa*; and a Line through the fourth and third touched the Eaſtern Limb of *Saturn*, *Fig.* 132. Fig. 132.

The firſt was Northward of the Line of the *Anſæ* (and therefore in the *Apogæon* Semicircle alſo) diſtant from the ſaid Line about as far as the End of the conjugate Axis of the Ring was from the Center of ♄, *viz.* nearly $\frac{1}{4}$ of *Saturn*'s Semidiameter; and it was about a Semidiameter of the Ring from the Weſtern *Anſa*.

The ſecond was a very little Southward of the Line of the *Anſæ* (and therefore in the *Perigæon* Semicircle) above a Semidiameter of the Ring + the Semidiameter of ♄) from the Weſtern *Anſa*. And the third, firſt and ſecond were in a ſtrait Line.

At 10^{h}. 50′. A Perpendicular from the third to the Line of the *Anſæ* fell almoſt on the Middle of the bright Part of the Eaſtern *Anſa*, but ſomewhat nearer the Center than the ſaid Middle.

April 22^{d}. 11^{h}. 5′. The four innermoſt Satellites were all Eaſtward of ♄. The 2^{d} and 4th in the *Apogæon*, and the 1^{ſt} and 3^{d} in the *Perigæon* Semicircle. A Line thro' the 2^{d} and 4th touched the *South-Eaſt* Limb of ♄. A Line paſſing through the 3^{d} and the End of the conjugate *Axis* of the Ring, was parallel to the Line of the *Anſæ*.

At 11^{h}. 10′. A Perpendicular from the firſt to the Line of the *Anſæ*, fell on the Eaſtern Extremity of the Ring, *Fig.* 133. Fig. 133.

Theſe Diſtances and Directions were taken only by Eſtimation, and not by any actual Meaſurement.

The fifth (or outermoſt) Satellite being at this time near its greateſt Elongation Eaſtward, among ſeveral very ſmall Teleſcopick Stars, he could not determine its Poſition. But by obſerving the Motion of this ſome other Nights before, he was now fully ſatisfied, from the Motions rectified as above, that there are five Satellites of *Saturn*, as Mr. *Caſſini* had long ſince aſſerted.

In the bright Part of each *Anſa* was a darkiſh Ellipſe nearer to the outſide than the inſide of the Ring, as if it was compoſed of two Rings near to one another.

On the Body of ♄, beſide the Ring on the *South*-ſide, there appeared on the *North*-ſide a Zone not ſo far from the Center as the Ring, and not much unlike the ſmalleſt of *Jupiter*'s Belts. Which Appearances were firſt taken Notice of by Mr. *Caſſini*, in *Phil. Tranſ.* † N° 128. *Vide Fig.* 134. † *Vid.* Supra V. I. C. IV. S. LXXVI. 14. Fig. 134.

It

It is not to be expected that theſe Satellites, exceedingly minute in themſelves, and ſo faintly illuminated, ſhould appear when the Air is but ordinarily ſerene, they requiring not only the *Medium* to be *ſummo modo* defecate and limpid, but withal in perfect Darkneſs. For which Reaſons it may well be underſtood why the Gentlemen of the *Pariſian* Obſervatory may have ſometimes made a Difficulty to undertake to ſhew them upon demand.

XXXVII. Nuperarum Obſervationum ope, facta aliquali Motuum caſtigatione, Teleſcopio *Hugeniano* omne Saturni Satellitium ipſi agnovimus; adhibitiſque accuratis Rev. D. *Jac. Pondi* obſervationibus, Tabulas ſubſequentes cœlo ſatis conſonas obtinuimus. Addendo ſc. motui annuo *Interioris*. 2 gr. 9′; *Penintimi* vero 3°. 25′. retentis Epochis D. *Caſſini* ad Annum 1686. Augendo etiam motum annuum *Extimi* 9 min. ſublatis vero 16 grad. ab *Epocha*, quæ in Epiſtola † N° 187. perperam ſcribitur ♈ 16°. 19′. pro ♓ 0°. 16′. *Hugenianum* 6′ annuatim tardiorem invenimus. *Tertii* autem Tabellas, ob motum diurnum falsò in Epiſtola illa traditum, de integro recudere neceſſe habuimus, retenta ſaltem *Epocha*.

Correct Tables *of the* Motions *of* Saturn's *five* Satellites, *by* — n. 356. p. 776.

† *Vid.* Supr. V. I. C. IV. S. LXXXII.

Tabula Mediorum Motuum Intimi Satellitis Saturni *à* Cassino *detecti Anno* 1686.

Annis Chri. ineunt	*Epochæ* s	°	′	″	*Annis*	*Mot. Med.* s	°	′	″	*Diebus*	*Mot. Med.* s	°	′	″	*H M*	*Mot. Med.* Sex.	°	′	″	*Min.*	*Mot. Med.* °	′
1681	♒	8	48		1	4	4	43		1	6	10	42		1	0	7	57		31	4	6
1686	♉	13	4		2	8	9	25		2	0	21	24		2	0	15	53		32	4	14
1701	♌	6	34		3	0	14	8		3	7	2	6		3	0	23	50		33	4	22
1714	♑	9	57		4	10	29	33		4	1	12	47		4	0	31	47		34	4	30
1715	♒	14	39		5	3	4	16		5	7	23	29		5	0	39	44		35	4	38
1716	♏	19	22		6	7	8	59		6	2	4	11		6	0	47	40		36	4	46
1717	♉	4	47		7	11	13	42		7	8	14	53		7	0	55	37		37	4	54
1718	♌	9	30		8	9	29	6		8	2	25	35		8	1	3	34		38	5	2
1719	♍	14	13		9	2	3	49		9	9	6	17		9	1	11	31		39	5	10
1720	♉	18	55		10	6	8	32		10	3	16	59		10	1	19	28		40	5	18
Men. Anni Com.	*Mot. Med.* s	°	′	″	11	10	13	15		11	9	27	41		11	1	27	24		41	5	26
					12	8	28	40		12	4	8	22		12	1	35	21		42	5	34
					13	1	3	23		13	10	19	4		13	1	43	18		43	5	42
Jan.	0	0	0		14	5	8	5		14	4	29	46		14	1	51	15		44	5	50
Febr.	5	1	38		15	9	12	48		15	11	10	28		15	1	59	11		45	5	58
Mar.	3	1	10		16	7	28	13		16	5	21	10		16	2	7	8		46	6	5
Apr.	8	2	48		17	0	2	56		17	0	1	52		17	2	15	5		47	6	13
Maii	6	23	44		18	4	7	39		18	6	12	34		18	2	23	1		48	6	21
Junii	11	25	22		19	8	12	21		19	0	23	16		19	2	30	58		49	6	29
Julii	10	16	19		20	6	27	46		20	7	3	57		20	2	38	55		50	6	37
Aug.	3	17	57		40	1	25	32		21	1	14	39		21	2	46	52		51	6	45
Sept.	8	19	35		60	8	23	19		22	7	25	21		22	2	54	49		52	6	53
Octob	7	10	31		80	3	21	5		23	2	6	3		23	3	2	45		53	7	1
Nov.	0	12	9		100	10	18	51		24	8	16	45		24	3	10	42		54	7	9
Dec.	11	3	5		120	5	15	37		25	2	27	27		25	3	18	39		55	7	17
In Anno Bissextili post Februarium adde unius diei motum.										26	9	8	9		26	3	26	35		56	7	25
										27	3	18	50		27	3	34	32		57	7	33
										28	9	29	32		28	3	42	28		58	7	41
										29	4	10	14		29	3	50	25		59	7	46
										30	10	20	56		30	3	58	22		60	7	57

Tabula Mediorum Motuum Saturni *Satellitis Penintimi, à* Cassino *inventi Anno* 1686.

Annis Jul. ineunt	*Epochæ* S	°	′	*Annis*	*Med. Mot.* S	°	′	*Diebus*	*Med. Mot* S	°	″	*H M*	*Med. Mot.* Sex. °	′	″	*Min.*	*Mot. Med.* ′	″
1681	♓	3	23	1	4	10	2	1	4	11	32	1	0	5	29	31	2	50
1686	♉	5	25	2	8	20	4	2	8	23	4	2	0	10	58	32	2	56
1701	♓	22	3	3	1	0	6	3	1	4	36	3	0	16	26	33	3	1
1714	♍	7	5	4	9	21	40	4	5	16	8	4	0	21	55	34	3	7
1715	♉	17	7	5	2	1	42	5	9	27	40	5	0	27	24	35	3	12
1716	♏	27	9	6	6	11	44	6	2	9	12	6	0	32	53	36	3	17
1717	♊	18	43	7	10	21	46	7	6	20	44	7	0	38	22	37	3	23
1718	♎	28	45	8	7	13	20	8	11	2	16	8	0	43	51	38	3	28
1719	♓	8	47	9	11	23	22	9	3	13	49	9	0	49	19	39	3	34
1720	♋	18	49	10	4	3	24	10	7	25	21	10	0	54	48	40	3	40
Mens. An. Co	*Mot. Med.* S	°	′	11	8	13	26	11	0	6	53	11	1	0	17	41	3	45
				12	5	5	0	12	4	18	25	12	1	5	46	42	3	51
				13	9	15	2	13	8	29	57	13	1	11	15	43	3	56
Jan.	0	0	0	14	1	25	4	14	1	11	29	14	1	16	44	44	4	1
Febr.	3	27	34	15	6	5	6	15	5	23	1	15	1	22	13	45	4	7
Mar	6	20	32	16	2	26	40	16	10	4	33	16	1	27	42	46	4	12
Apr.	10	18	6	17	7	6	42	17	2	16	5	17	1	33	11	47	4	17
Maii	10	4	7	18	11	16	44	18	6	27	37	18	1	38	39	48	4	23
Junii	2	1	41	19	3	26	46	19	11	9	9	19	1	44	8	49	4	28
Julii	1	17	43	20	0	18	20	20	3	20	41	20	1	49	37	50	4	34
Aug.	5	15	17	40	1	6	40	21	8	2	13	21	1	55	6	51	4	39
Sept.	9	12	51	60	1	25	0	22	0	13	45	22	2	0	35	52	4	45
Oct.	8	28	53	80	2	13	20	23	4	25	17	23	2	6	4	53	4	50
Nov.	0	26	27	100	3	1	4	24	9	6	49	24	2	11	32	54	4	56
Dec.	0	12	28	120	3	20	0	25	1	18	22	25	2	17	1	55	5	1
								26	5	29	54	26	2	22	30	56	5	7
In Anno Bissextili post Februarium adde unius diei motum.								27	10	11	26	27	2	27	59	57	5	12
								28	2	22	58	28	2	33	27	58	5	18
								29	7	4	30	29	2	38	56	59	5	23
								30	11	16	2	30	2	44	25	60	5	29

Tabula Mediorum Motuum Satellitis Saturni *Medii, à* Cassino *detecti Anno* 1671.

Annis Jul. ineunt	*Epochæ.*			*Annis*	*Med. Mot.*			*Diebus*	*Med. Mot.*			*H M*	*Med. Mot.* Sex.			*M*	*Med. Mot.*	
	s	°	′		s	°	′		s	°	′		°	′	″		′	″
1681	♑	12	16	1	9	17	2	1	2	19	41	1	0	3	19	31	1	43
1686	♏	27	6	2	7	4	3	2	5	9	23	2	0	6	38	32	1	46
1701	♐	1	17	3	4	21	5	3	7	29	4	3	0	9	58	33	1	49
1714	♐	11	43	4	4	27	48	4	10	18	46	4	0	13	17	34	1	53
1715	♑	28	45	5	2	14	50	5	1	8	27	5	0	16	36	35	1	56
1716	♉	15	47	6	0	1	52	6	3	28	9	6	0	19	55	36	2	0
1717	♉	22	30	7	9	18	53	7	6	17	50	7	0	23	15	37	2	3
1718	♓	9	32	8	9	25	36	8	9	7	31	8	0	26	34	38	2	6
1719	♐	26	34	9	7	12	38	9	11	27	13	9	0	29	53	39	2	10
1720	♐	13	35	10	4	29	40	10	2	16	54	10	0	33	12	40	2	13
Mens	*Med. Mot.*																	
Anni				11	2	16	42	11	5	6	36	11	0	36	31	41	2	16
Com.	s	°	″	12	2	23	25	12	7	26	17	12	0	39	51	42	2	19
				13	0	10	26	13	10	15	59	13	0	43	10	43	2	23
Jan.	0	0	0	14	9	27	28	14	1	5	40	14	0	46	29	44	2	26
Febr.	10	10	24	15	8	14	30	15	3	25	21	15	0	49	48	45	2	29
Mar.	0	21	44	16	7	21	13	16	6	15	3	16	0	53	8	46	2	33
Apr.	11	2	9	17	5	8	15	17	9	4	44	17	0	56	27	47	2	36
Maii	6	22	51	18	2	25	16	18	11	24	26	18	0	59	46	48	2	39
Junii	5	3	16	19	0	12	18	19	2	14	7	19	0	3	5	49	2	43
Julii	0	23	58	20	0	19	1	20	5	3	49	20	1	6	24	50	2	46
Aug.	11	4	23	40	1	8	2	21	7	23	30	21	1	9	44	51	2	49
Sept.	9	14	47	60	1	27	4	22	10	13	11	22	1	13	3	52	2	53
Oct.	5	5	30	80	2	16	5	23	1	2	53	23	1	16	22	53	2	56
Nov.	3	15	54	100	3	5	6	24	3	22	34	24	1	19	41	54	2	59
Dec.	1	6	37	120	3	24	7	25	6	12	16	25	1	23	1	55	3	3
								26	9	1	57	26	1	26	20	56	3	6
In Anno Biſſextili poſt Februarium adde unius Diei motum.								27	11	21	39	27	1	29	39	57	3	9
								28	2	11	20	28	1	32	58	58	3	13
								29	5	1	1	29	1	36	17	59	3	16
								30	7	20	43	30	1	39	36	60	3	19

Tabula Mediorum Motuum Penextimi Satellitis Saturni *ab* Hugenio *inventi Anno* 1655.

Annis Jul. ineunt	*Epochæ*			*Annis*	*Med. Mot.*			*Diebus*	*Med. Mot*			*H M*	*Mo. Me.*		*Min.*	*Motus Medi.*	
	S	o	'		S	o	'		S	o	"		°	' "		'	"
1641	♍	2	48	1	10	20	35	1	0	22	35	1	0	56	31	29	10
1661	♓	13	23	2	9	11	10	2	1	15	9	2	1	53	32	30	6
1681	♈	27	58	3	8	1	45	3	2	7	44	3	2	49	33	31	3
1686	♏	3	28	4	7	14	55	4	3	0	18	4	3	46	34	31	59
1701	♊	12	33	5	6	5	30	5	3	22	53	5	4	42	35	32	55
1714	♓	17	53	6	4	26	5	6	4	15	28	6	5	39	36	33	52
1715	♒	8	28	7	3	16	40	7	5	8	2	7	6	35	37	34	48
1716	♐	29	3	8	2	29	50	8	6	0	37	8	7	31	38	35	45
1717	♐	12	13	9	1	20	25	9	6	23	12	9	8	28	39	36	41
1718	♏	2	48	10	0	11	0	10	7	15	46	10	9	24	40	37	38
1719	♑	23	23	11	11	1	35	11	8	8	21	11	10	21	41	38	34
1720	♌	13	58	12	10	14	45	12	9	0	55	12	11	17	42	39	31
1721	♋	27	8	13	9	5	20	13	9	23	30	13	12	14	43	40	27
				14	7	25	55	14	10	16	5	14	13	10	44	41	24
Mens. An. Co	*Mot. Med.* S	o	'	15	6	16	30	15	11	8	39	15	14	7	45	42	20
Jan.	0	0	0	16	5	29	40	16	0	1	14	16	15	3	46	43	17
Febr.	1	9	54	17	4	20	15	17	0	23	48	17	16	0	47	44	13
Mar	8	12	2	18	3	10	50	18	1	16	23	18	16	56	48	45	10
Apr.	7	21	55	19	2	1	25	19	2	8	58	19	17	52	49	46	6
Maii	6	9	14	20	1	14	35	20	3	1	32	20	18	49	50	47	3
Junii	5	19	7	40	2	29	10	21	3	24	7	21	19	45	51	47	59
Julii	4	6	26	60	4	13	45	22	4	16	42	22	20	42	52	48	56
Aug.	3	16	18	80	5	28	20	23	5	9	16	23	21	38	53	49	52
Sept.	2	26	12	100	7	12	55	24	6	1	51	24	22	35	54	50	49
Oct.	1	13	30	120	8	27	30	25	6	24	25	25	23	31	55	51	45
Nov.	0	23	34	140	10	12	5	26	7	17	0	26	24	27	56	52	42
Dec.	11	10	42	160	11	26	40	27	8	9	35	27	25	24	57	53	38
								28	9	2	9	28	26	20	58	54	35
In Anno Biſſextili poſt Februarium adde unius diei motum.								29	9	24	44	29	27	17	59	55	31
								30	10	17	18	30	28	13	60	56	27

Tabula

Tabula Mediorum Motuum Satellitis Saturni *Eximi, à* Caſſino *detecti Anno* 1671.

Annis Jul. ineunt	*Epochæ.*			*Annis*	*Med. Mot.*			*Diebus*	*Med. Mot.*			*H M*	*Mo. Me.*		*M*	*Med. Mot.*	
	S	°	′		S	°	′		S	°	′		°	′		′	″
1681	♈	8	40	1	7	6	32	1	0	4	32	1	0	11	31	5	51
1686	♈	15	50	2	2	13	3	2	0	9	5	2	0	23	32	6	3
1701	♉	11	53	3	9	19	35	3	0	13	37	3	0	34	33	6	14
1714	♓	20	20	4	5	0	39	4	0	18	9	4	0	45	34	6	25
1715	♎	26	52	5	0	7	10	5	0	22	42	5	0	57	35	6	37
1716	♊	3	23	6	7	13	42	6	0	27	14	6	1	8	36	6	48
1717	♍	14	27	7	2	20	13	7	1	1	44	7	1	19	37	7	0
1718	♌	20	58	8	10	1	17	8	1	6	18	8	1	31	38	7	11
1719	♓	27	30	9	5	7	49	9	1	10	51	9	1	42	39	7	22
1720	♏	4	2	10	0	14	20	10	1	15	23	10	1	53	40	7	34
Men. Anni Com.	*Med. Mot.*			11	7	20	52	11	1	19	55	11	2	5	41	7	45
	S	°	″	12	3	1	56	12	1	24	28	12	2	16	42	7	56
				13	10	8	27	13	1	29	0	13	2	27	43	8	8
Jan.	0	0	0	14	5	14	59	14	2	3	32	14	2	39	44	8	19
Febr.	4	20	41	15	0	21	30	15	2	8	5	15	2	50	45	8	30
Mar.	8	27	46	16	8	2	34	16	2	12	37	16	3	1	46	8	42
Apr.	1	18	27	17	3	9	6	17	2	17	9	17	3	13	47	8	53
Maii	6	4	37	18	10	15	37	18	2	21	42	18	3	24	48	9	4
Junii	10	25	18	19	5	22	9	19	2	26	14	19	3	35	49	9	16
Julii	3	11	27	20	1	3	13	20	3	0	46	20	3	47	50	9	27
Aug.	8	2	9	40	2	6	26	21	3	5	18	21	3	58	51	9	38
Sept.	0	22	50	60	3	9	38	22	3	9	51	22	4	9	52	9	50
Oct.	5	8	59	80	4	12	51	23	3	14	23	23	4	21	53	10	1
Nov.	9	29	41	100	5	16	4	24	3	18	55	24	4	32	54	10	12
Dec.	2	15	50	120	6	19	17	25	3	23	28	25	4	43	55	10	24
								26	3	28	0	26	4	55	56	10	35
In Anno Biſſextili poſt Februarium adde unius Diei motum.								27	4	2	32	27	5	6	57	10	46
								28	4	7	5	28	5	17	58	10	58
								29	4	11	37	29	5	29	59	11	9
								30	4	16	9	30	5	40	60	11	21

Motibus

Motibus mediis Satellitum ad hunc modum conſtitutis, proveniunt Revolutiones eorum jam veris proximæ, ſcilicet

	D.	h	′	″
Primi ſive Intimi	1	21	18′	26″ ½
Secundi Penintimi	2	17	41	10 ½
Tertii ſive *Medii*	4	12	25	10
Quarti Hugeniani	15	22	41	28
Quinti ſive *Extimi*	79	7	46	00

Poſito autem, juxta regulam Naturæ (ſaltem in hoc noſtro Syſtemate) univerſalem, quæque tam in Jovialium ac Lunæ motibus, quam Planetarum Primariorum circa Solem, obtinet, Vires centrum Saturni petentes eſſe in duplicatâ ratione diſtantiarum reciprocè, ac proinde Cubos diſtantiarum à centro eſſe ut quadrata Temporum periodicorum; ex data diſtantia & periodo *Hugeniana*, fiunt reliquorum diſtantiæ ut ſequitur,

	Semidiam. Annuli.	*Semidiam. Globi* ♄.
Diſt. Primi	1.9289	4.3400
Secundi	2.4708	5,5593
Tertii	3.4508	7,7643
Quarti	8.0000	18,0000
Quinti	23.3146	52,4578

Quæ quidem diſtantiæ cum D. *Caſſini* obſervatis ſatis quadrant. Quatuor autem interiores Satellites juxta planum Annuli Saturni orbitas ſuas deſcribunt proximè; in plano, *ſc.* Æquatoris noſtri plano quoad ſenſum parallelo, quicquid in contrarium proferant nonnulli. Quintum vero orbem ſitu paulo diverſum à cæteris deſcribere, nuper deprehendit D. *Jac. Caſſinus* prioris filius, & virtutum hæres, *Act. Acad. Scient. Pariſ. Anni* 1714.

XXXVIII. Obſervationes ſequentes (quas in unum congeſſimus) ſunt accuratiſſimæ, utpote Tubis prælongis ac Micrometris præter ſolitum affabre factis menſuratæ.

Anno 1717, *Aprilis* 15°. 9ʰ 49′ T. æq. obſervavit D. *Pound* apud *Wanſted*, *Jovem* jam reverſum ad ſtellam illam, quam *Novemb.* 22°. 1716. manè corpore ſuo texerat, de qua vide *Phil. Tranſ.* N. 350. * *Jovis* autem centrum tum temporis diſtabat ab ea Stella (quæ tertia eſt Geminorum in *Catalogo Britannico*) 23′ 22″ boream verſus; ſimulque ab alia vicinâ, quæ quarta eſt Geminorum in dicto Catalogo, 27′ 11″ atque huic fere conjunctus erat planeta.

Aprilis 25ᵗᵒ ſequente, eodem obſervatore ac loco, 10ʰ 3′ T. æq. *Jupiter* apud quatuor Fixas exiguas viſus eſt, eas omnes præcedens, & in ipſo quaſi principio Cancri. Centrum autem planetæ diſtabat ad *e* 13′ 00″, ab *b* 11′ 32″, ab *f* 19′ 53″, & à *g* 9′ 27″.

Poſtridie vero *Apr.* 26°. 9ʰ′ 7″ *Jovis* centrum diſtabat ab *e* 8′ 35″, ab *f* 9′ 00″, à *g* 4′ 5″, & ab *b* 13′ 50″. Jamque præterierat omnes præ-

A Collection *of* Aſtronomical *Obſervations for* 1717, 1718. *by* — n.357. p.840. — *of the* Planets.

* *Vid.* Supra p. 319. n.354. p.723.

ter *f* ad quam tendebat, quamque parum admodum die craſtino infra ſe relinquere debuit.

Eodem fere momento, horâ ſcil. nonâ, *Londini* viſa eſt ſtella *g* in vertice Trianguli Iſoſcelis ac fere Iſopleuri cum *Jovis* centro ac tertio Satellite, tum ſex *Jovis* diametris ad occaſum diſtante, niſi quod parum admodum baſe longiora erant crura; ac intra quadrantem horæ, angulus ad *Jovis* centrum, qui prius major erat angulo ad Satellitem, factus eſt eo ſenſibiliter minor.

Tres autem Stellæ *h*, *g*, *e*, ſunt 10ma, 11ma, & 12ma. Geminorum in *Catal. Britan.* juxta quem tum temporis ſitum habuere, *h* in ♋ 0° 22′ 55″, cum Latit. borea 0° 11′ 25″. Et *g* in ♋ 0° 28′ 25″. Lat. bor. 0° 3′ 40″: *e* vero in ♋ 0° 29′ 20″ cum Lat. auſt. 0° 8′ 05″. Diſtat autem quarta *f* à Stella *g* 11′ 40″, ab *e* 12′ 50″. ac denique ab *h* 20′ 36″, unde conſtabit locus ejus. Ex his manifeſtum eſt *Jovem* Latitudinem habuiſſe parvam admodum borealem, nec ſemiminuto majorem, ſaltem ſi dictis ſtellarum locis habenda fides. Hæc poſteris uſui eſſe poſſunt definiendo Nodorum *Jovis* motum, ſi quem habeant.

Ejuſdem anni *Junii* 18vo 10h *Londini*, in ædibus Societatis Regiæ, viſus eſt *Saturnus* Stellæ fixæ Teleſcopicæ admodum propinquus, à qua vix diſtabat ad Auſtrum una Annuli diametro, & normalis in lineam Anſarum à Stella demiſſa incidebat in medium Anſæ orientalis. Fixa hæc parvula nullique Catalogo adſcripta tunc habuit ♎ 12° 58′ ½ cum Lat. bor. 2° 33′ proximè; comitemque habet ſibi adjunctam ac luce æqualem, quatuor minutis ad ortum diſtantem, ac paulo auſtraliorem, unde facile dignoſci poterit, locuſque ejus ſi cui libeat verificari.

Eadem nocte 10h 30′ *Mars* viſus eſt prope Stellam quæ præcedit 35. *Scorpii*, à qua diſtabat Tubo 24 pedum menſurata 7′ 16″; idque in recta per claram in pede Ophiuchi θ & dictam Stellam producta. Hæc autem Stella præcedit 35. *Scorpii* 30′ 27″. Aſc. rect. eâque auſtralior eſt 2′ 28″, unde fit locus ejus tum temporis *Sagitt.* 15° 24′ 20″. Lat auſt. 3° 59′ 25″. Sed θ Ophiuchi tunc habuit *Sagitt.* 17° 28′, & Lat. auſt. 1° 47′ 38″. *Mars* itaque Stellam præcedebat Longitudine 4′ 58″, auſtralior ea 5′ 30″.

Deinde *Sept.* 13° 8h 30′ T. æq. *Mars* viſus eſt à Dom. *Pound* præcedere claram in humero *Sagittarii* σ 11′ 54″. Hora 8h 25′ erit diſtantia Planetæ à Stella 25′ 00″ accuratè.

Decemb. 5. 18h 30′. T. æq. conſenſu ſæpius repetitarum obſervationum, invenit D. *Pound Saturnum* præcedere Teleſcopicam claram ſibi vicinam 27′ 19″. Aſc. rect. rect. Stellaque auſtraliorem eſſe 1′ 59″. Simul *Saturnis* præcedebat κ in Syrmate *Virginis* 1° 25′ 21″, eâque auſtralior erat 4′ 05″. Hinc *Saturni* locus *Libr.* 29°. 16′ 21″. Lat. bor. 2° 22′ 21″. Teleſcopica autem tunc habuit *Libr.* 29° 40′ 56″. Lat. bor. 2° 33′ 43″.

Anno 1718. *Jan.* 7. 5h. 30′. T. æq. *Venus* apud duas Stellas in *Catal. Britan.* omiſſas obſervata eſt. Erat autem Planeta utraque Fixâ borealior, diſtans à præcedente 32′ 30″, à ſequente 17′ 30″. Stella præ-

cedens tunc habuit *Piſc.* 14° 42′ 20″, cum Lat. Auſt. 0° 40′ 10″; altera vero ſequens *Piſc.* 15° 21′ 55″, Lat. Auſtral. 0°. 27′ 15″, prout ex obſervationibus D. *Flamſtedii* colligere licet.

Jan. 15. 8ʰ 00′, T. æq. *Jupiter* præcedebat ϒ in pectore *Cancri* 3° 30′ 50″ Aſc. Rect. fixâque auſtralior erat 14′ 15″. Hinc provenit *Jovis* locus *Canc.* 28° 20 cum Latitudine Borea 0° 36′ 45″.

Martii 11. 10ʰ 36′, T. æq. *Saturnus* præcedebat ϰ in Syrmate *Virginis* 18′ 51″, eâque Fixâ auſtralior erat 5′ 23″. Hinc fit locus *Saturni Scorp.* 0. 18′ 34″ cum Lat. Bor. 2. 44′ 8″. Poſito ſcilicet, juxta *Catal. Britan.* ϰ *Virginis* occupare ♏ 0. 34′ 10″, cum Lat. 2. 55′ 40″. Eadem nocte 17ʰ 00′ *Weſtmonaſterii* obſervarunt D D. *Deſaguliers* & *Gray Saturnum* præcedere Stellam 19′ 00″ cum Declinatione majore in Auſtrum 4′ 45″.

April. 8. 11ʰ 30′ *Londini* viſus eſt *Saturnus* nuper Acronychus parum admodum occidentalior Teleſcopicâ clarâ, eâdemque 5 minutis borealior. Unde Fixæ locus *Libræ* 28. 18′ 30″ Lat. Bor. 2. 41′. Circulus autem magnus per hanc Stellam & *Saturnum* ductus dirigi videbatur ad Stellam 5ᵗᵉ magnitudinis in *Catal. Brit.* omiſſam, ſed quæ *Hevelio* eſt *in cuſpide Alæ Boreæ Virginis*, cuique locum aſſignat *Libr.* 26. 10′, cum Lat. 14. 43′ Bor.

Eadem nocte 13ʰ 20′, apud *Wanſted*, perpendiculum à dictâ Stellâ Teleſcopica in lineam Anſarum *Saturni* demiſſum præcedebat Centrum planetæ quaſi ſeſquialtera diametro annuli; aberat autem Stella ad Auſtrum ab Anſarum axe 4′ 30. Simul Anſæ orientalis extremitas deprehenſa eſt in linea recta inter hanc Stellam & aliam eidem quaſi longitudine conjunctam, quæ tunc à *Saturno* diſtabat 24′ 48″ verſus Boream. Locus autem prioris Stellæ tunc fuit *Libr.* 28. 18′ 30″ cum Lat. Bor. 2. 41′ proxime.

Sept. 7. circa meridiem incidit conjunctio *Jovis* & *Veneris* arctiſſima, cujus quidem ſpectaculum Aſtronomis noſtris inviderunt Nubes. Die autem ſexto præcedente mane, vel 5ᵈ 22ʰ 57′ 30″ T. æq. apud *Wanſted*, *Venus* occidentalior diſtabat à *Jove* 1. 3′ 28″. Die autem 7. 17ʰ 21′, *Venus* jam facta orientalior à *Jove* aberat 43′ 18″; ac 17ʰ 34′, *Venus* auſtralior erat *Jove* differentiâ declinationum 14′ 23″. Et 17ʰ 39′ capta eſt diſtantia Planetarum 44′ 4″. Hinc calculo accuratiſſimi Obſervatoris conjuncti ſunt *Sept.* 7. 0ʰ 9′ T. æq. *Veneris* centro tum *Jovis* auſtraliore non niſi 1′ 42″.

Sept. 18. Mane, apud *Wanſted*, *Jupiter* viſus eſt prope *Cor Leonis*, quocum die præcedente conjunctus fuerat, *Sept.* 17. 16ʰ 51′ T. æq. *Jovis* centrum aberat à *Corde Leon.* 24′ 22″; & 17ʰ 6′ 20″ erat diff. Declin. 12′ 43″. Dein poſt Horam, nempe 17ʰ 54′, facta eſt diſtantia 24′ 44″; ac 18ʰ 7′ differentia Declinationum inventa eſt 12′ 35″. Hinc ſupputante Dom. *Pound*, fit *Sept.* 17. 18ʰ 00′ T. æq. *Jovis* locus ♌ 26 11′ 7″ cum Lat. Bor. 45′ 32″.

— *of the* Moon *and* Eclipſes.

Anno 1717. *Jan.* 12. *Weſtmonaſterii* obſervavit Dom. *Stephanus Gray* Lunæ appulſum ad quatuor Stellas contiguas ſub cornu Auſtrino *Tauri*, apud quas obſervata eſt Luna Anno 1683. *Mart.* 23. ſt. v. ab *Hevelio* & *Flamſtedio*. Itaque 9^h 45′ T. app. Luna gibba viſa eſt quaſi conjuncta cum Stella è quatuor præcedente, quæ eſt *Tauri* 107. *Catal. Brit.* quæque tunc auſtralior erat Lunæ limbo auſt. ſeſquialtero minuto, 11^h 29′ altera, quæ minor eſt, & ideo in Catalogo omiſſa, occultabatur paulo infra medium obſcuri limbi. Ad 12^h 24′ Tertia & clarior (110. *Tauri*) in ipſa fere conjunctione ſex minutis diſtabat à limbo boreo. Denique 12^h 54′ ſequens è quatuor (111 *Tauri*) limbo boreo ſuperior erat 3′ 30″. Locus autem præcedentis, ſive 107. *Tauri*, ex dicto Catalogo tunc erat *Gemini* 18. 12′. Lat. auſt. 5. 18′; *Tauri* autem 110 habuit *Gem.* 19. $26'\frac{1}{4}$ cum Lat. auſt. 4. 44′: Sequens vero, ſive 111 *Tauri*, erat in *Gem.* 19. 45′. Lat. auſt 4. $48'\frac{1}{6}$. Secunda parvula, ut ex aliis obſervationibus conſtat, Locum tunc habuit *Gem.* 19. 17′. Lat. 5. 5′ ferè.

Eodem anno *Mart.* 16. mane, erat Eclipſis Lunæ partialis, apud nos ob cœlum nubilum inconſpicua. At apud *Cambrig. Nov. Anglorum*, Dom. *Robie* Aſtronomiæ peritiſſimus vidit Eclipſeos initium circa horam nonam. Finem vero, juxta *Paludem Mæotida*, ad 11^h 42′ 30″ ſat accuratè. Eſt autem *Cambridg.* ſub altitudine Poli 42 25′, *Londino* 71. grad. ſive 4^h 44′ occidentalior, ut ex pluribus antea obſervatis conſtant.

Vid. Infra p. 338.

Dein *Sept.* 9. veſperi, in ædibus Societatis Regiæ *Londini*, obſervarunt nonnulli finem Eclipſeos Lunaris 7^h 26′. Luna autem orta eſt juxta medium Eclipſeos, nec niſi paulo ante finem è nubibus horizontem obſidentibus ſeſe extricaverat.

Sept. 14. Veſperi, hac prima vice poſt longum intervallum rediit Luna ad occultandum *Palilicium*. Cœlum etiam *Londini* præter ſolitum purum, ita ut Luna & Stella exorientes in ipſo quaſi Horizonte ſimul conſpicerentur. Incidit Immerſio Stellæ 9^h 6′ 20″, Lunâ nondum 3° altâ, in ipſo quaſi medio Limbi orientalis, è regione ſcilicet boreæ partis maculæ illius exiguæ quam *Hevelius* Stagnum *Mæridis* vocat, quamque *Ricciolus* ſui ipſius nomine inſignivit. Emerſit autem paulo infra medium limbi obſcuri ad 9^h 58′ 20″, in ictu oculi tota ſua claritate effulgens; unde etiam in tam illuſtri Stellâ quaſi nullitas diametri demonſtratur.

Septembris 23. Veſperi, incidit Eclipſis Solis vix ullibi in *Europâ* conſpicua. Ex *America* autem noſtrâ duplicem obtinuimus ejus obſervationem; alteram ex literis illuſtris Viri D. *Keith* Provinciæ *Penſylvaniæ* Præfecti digniſſimi, qui *Philadelphiæ*, ſub altitudine Poli 40° 00′ fere, vidit Eclipſin jam cœptam (ſed quæ ante minutum temporis nondum inceperat) ad 11^h 55′. Circa medium Digiti erant quaſi decem. Finis autem viſus eſt accurate ad 2^h 46′ 35″.

Altera autem hujus obſervatio habita eſt ad *Cambridge Novæ Angliæ* Academiam, à Dom. *Robie.* Initium Eclipſeos ibi obſervatum eſt 0^h 23′ 00″ poſt meridiem. Ad 1^h 47′ defecêre IX Digiti. Ad 3^h 5′ 10″ deſiit Eclipſis. Sole integro per Tubum 24 pedum conſpecto. Hæc ex literis accurati Obſervatoris communicavit D. *Guil. Derham.*

Dec. 5. Luna paulo ſupra *Palilicium* invecta eſt: Tranſitum autem ſatis arctum obſervavit D. *Jac Bradley*, A. M. eruditus Juvenis; Hic, cum Luna jam propemodum plena eſſet, Stellam contulit cum inſigni illa Macula quam *Ricciolus Tychonem*, *Hevelius Sinam* appellat, & ex pluribus æqualibus diſtantiis Micrometro ante & poſt captis, Stellam dictæ maculæ centro proximam apparuiſſe concluſit ad 11^h 15′ 8″ T. æq. apud *Wanſted.* Ad 11^h 15′ 42″ diſtabat Palilicium à limbo Lunæ proximo & auſtrino 5′ 55″. Macula autem *Tycho* ab eodem limbo aberat 4′ 16″. Ad 11^h 18′ 42″ Stella erat in lineâ rectâ cum maculis *Tychonis* & *Copernici*, ſive *Sinæ* & *Ætnæ*; & 11^h 25′ 27″. T. æq. erat in rectâ cum *Tychone* & *Keplero.* Inter hæc obſervata eſt Lunæ diameter 32′ 45″.

Anno 1718. *Jan.* 29. veſperi, DD. *Deſaguliers* & *Gray*, *Weſtmonaſterii* alteram *Palilicii* Occultationem præſtolabant; ſed nubium interventu impediti, viderunt ſaltem quod 5^h 52′ nondum immerſerat Stella; attenuatis autem poſtea nubibus concluſa eſt Emerſio ad 7^h 20′, è regione Promontorii *Sarmatiæ Aſiaticæ Hevelii.*

Feb. 19. mane, iidem obſervatores ibidem variè cum nubibus colluctati Eclipſin Solis ægre conſpexerunt: Horâ tamen 6. 59′ viſi ſunt deficere duo Digiti, & poſt unum temporis minutum chorda inter Cuſpides viſa eſt æqualis ſemidiametro Solis.

Apud *Wanſted* autem D. *Pound* notavit ad 6^h 54′ 7″ T. app. chordam inter Cuſpides 18′ 30″. Ad 7^h 17′ 00″ erat 10′ 18″. Ad 7^h 19′ 30″ eadem inventa eſt 8′ 05″. Deſiit autem Eclipſis 7^h 23′ 20″.

Feb. 25. veſperi, 6^h 44′ T. app. *Weſtmonaſterii*, Stella prima *Hyadum* in Naribus *Tauri* (*γ Bayero*) viſa eſt in rectâ per Cuſpides Lunæ, adeoque propemodum conjuncta; diſtabat autem à limbo Lunæ auſt. 5′ 51″. Diameter Lunæ 31′ 45″ menſurata Micrometro.

Feb. 28, 8^h 36′ T. app. etiam *Weſtmonaſterii*, viſa eſt Immerſio Stellæ in poplite *Pollucis* (λ Geminorum *Bayero*) ſub limbi *Lunæ* obſcuri ea parte, quæ paulo borealior erat macula quam *Hevelius Cretam* vocat. Emerſio ipſa ob cœlum minus parum non conſpecta eſt: ſed ad 9^h 51′ egreſſa erat Stella è regione boreæ partis Inſulæ Majoris *Caſpii.*

Aug. 8. Luna orta eſt paulo infra *Palilicium*, cum quo tamen ob nubes conferri non potuit. Apud *Wanſted* autem 13^h 2′ 00″ T. app. viſa eſt Præcedens contiguarum ad *σ Tauri Bayero*, (ſive Penultima in noſtro *Hyadum* Catalogo, in N. 354. *Phil. Tranſ.* † litera *q* notata) in linea recta per Cuſpides *Lunæ*, diſtans ab Auſtrino 4′ 36″. Ad 13^h 7′ 25″ Stella *p* ejuſdem Catalogi emerſit paulo infra medium obſcu-

Vid. Supra p. 300.

obſcuri limbi. Ad 13^{h}. 19′ 4″ emerſit Sequens contiguarum dictarum, tantum diſtans à Cornu auſtrino quantum contiguæ illæ inter ſe, hoc eſt 7 min.

Aug. 29. Veſperi, Luna fere Apogæa paſſa eſt deliquium totalem ac fere centralem: orta autem eſt Eclipſi jam cœptâ. Hujus obſervationes maximè luculentas exhibuit Rev. D. *Pound*, eo ordine quo notatæ ſunt, nempe

Obſerv.	*Tmpus apparens* h	′	″	*Eclipſis* Lunæ *obſervata apud* Wanſted, 29 *Auguſti*, 1718.	′	″
1	6	53	38	Chorda inter Cuſpides Micrometro menſurata	22	37
2		55	8	Eadem repetita	21	14
3		56	31	Repetita	19	51
4		57	49	Iterum	18	28
5		59	38	Denuo	15	00
6	7	2	41	Immerſio Totalis in Umbram		
7	8	36	13	Stella clara in Catalogis omiſſa occultata eſt à *Lunâ*, infra *Paludem Mareotida Hevelii*	10	2
8	8	48	18	*Luna* cœpit emergere ex Umbra		
9		51	13	Terminus Umbræ per med. *Mareotidis*; ſimul Chorda inter Cuſpides	15	0
10		53	7	Chorda inter Cuſpides	18	28
11		54	16	Eadem repetita	19	51
12		54	59	Iterum	21	14
13	8	56	18	Denuo	22	37
14	9	0	48	*Porphyrites* emerſit ex Umbra		
15		8	3	Mons *Sinai* incepit emergere		
16		9	17	Umbra per medium *Sinæ*		
17		10	6	Jam totus *Sinai* extra Umbram		
18		11	20	Umbra per medium *Ætnæ*		
19		17	23	Per medium *Corſicæ*		
20		20	0	Per medium *Lacus Nigri majoris*		
21		27	54	Per medium *Besbici*		
22		28	45	Emerſit Stella prædicta		
23		32	34	*Byzantium* & *Horminius* ſimul emergunt		
24		33	58	Stella eandem habuit Declinationem cum Cuſpide Auſt. Eclipſeos		
25		43	28	Chorda inter Cuſpides	18	28
26		47	2	Eadem repetita	15	00
27	9	53	0	Deſiiſſe videbatur Defectus		

10ʰ 30′, Capta eſt Lunæ diameter 29′ 45″. Collatis autem inter ſe Obſervationibus, ubi Chordæ partis deficientis æquales deprehenſæ ſunt, provenit Eclipſeos medium.

	Medium. h. ′ ″
Ex Obſerv. prima & decima tertia	7 54 58
Ex ſecunda & duodecima	7 55 3
Ex tertia & undecima	7 55 24
Ex quarta & decima	7 55 28
Ex quinta & nona	7 55 25
Ex ſexta & octava	7 55 29
Quorum omnium Medium fit	7 55 18

Non minore cum curâ eandem Eclipſin, *Londini* in vico *Fleetſtreet*, inſtrumentis & Teleſcopio optimo D. *Geo. Graham* Automatopœi præſtantis, obſervavit D. *Martinus Folkes* Armig. cum aliis quibuſdam Regiæ Societatis Sodalibus, ut ſequitur,

h. ′ ″	
6 38 0	Luna per fumum Urbis & Vapores ægre viſa.
6 54 13	Chorda inter Cuſpides utcunque, 21′ 17″.
7 2 0	Immerſio Totalis in umbram.
7 42 15	Stella fixa ſatis clara diſtabat in limbo Lunæ orientali 19′ 21″.
8 35 18	Eadem fixa occultata eſt, 10′ circiter minutis centro Lunæ auſtralior.
8 45 50	Vel, ut quibuſdam viſum eſt, uno minuto tardius Luna cœpit emergere.
8 49 38	Palus *Mareotis* primo margine emerſit.
8 50 14	Integra Palus extra Umbram.
9 0 5	Montis *Porphyritidis* medium emerſit.
9 7 39	Primus margo *Sinæ* emerſit.
9 9 8	Mons *Sinai* totus extra umbram.
9 10 35	Umbra per medium *Ætnæ*.
9 12 0	Totus mons *Ætna* extra umbram.
9 18 51	Umbra per medium *Lacus Nigri* majoris.
9 27 35	Inſula *Beſbicus* tota emerſit.
9 42 21	Chorda inter Cuſpides 19′ 9″.
9 51 25	Finis Eclipſeos ut quibuſdam viſum eſt.
9 52 45	Finis ex præcedente diſtantia Cuſpidum concluſa.
9 56 45	Lunæ diameter 29′ 54″, iterumque 29′ 48″.

Erat autem Umbra admodum diluta, unde orta eſt difficultas in dijudicandis Emerſionis & Finis momentis: Atque Maculæ etiam obſcuriores clarè conſpectæ ſunt, pluribus minutis antequam Umbræ marginem

ginem attingerent. Stella vero quæ durante Eclipſi occultata eſt, locum tunc habuit ♓ 17° 16′½ cum Lat. auſt. 1° 6′ 30″ proximè.

Recepimus etiam Obſervationes hujus Eclipſeos à Rev. Dⁿᵒ *Derham* apud *Upminſter* in agro *Eſſexienſi* habitas; à Dⁿᵒ *Wright* apud *Crew* in agro *Ceſtrienſi*; & à Dⁿᵒ *Hawkins* apud *Wakefield* in *Eboracenſi*, cum præmiſſis ubique fere conſentientes, ſi adhibeantur meridianorum differentiæ: poſito ſcil. quod *Upminſter* ſit 1½ min. *Londino* orientalius, *Crew* vero 10 min. *Wakefield* 5 min. occidentaliora.

Denique Coronidis loco Obſervationem adjiciamus, eximiam, quidem, ſuique generis, quod ſcimus, ab invento Teleſcopio primam; quamque indefeſſæ D. *Jac. Bradley* debemus diligentiæ. Quinto enim *Septembris* manè, Sole jam fere 30 gr. alto, vidit apud *Wanſted* arctiſſimum Lunæ infra *Palilicium* tranſitum, cujus diſtantiam à limbo proximo, ad 7ʰ 59′ 00″ T. æq. Micrometro invenit 5′ 38″. Ad 8ʰ 17′ 5″ diſtabat à limbo 1′ 25″. Stella autem ad 8ʰ 33′ 15″ erat in linea recta per Lunæ Cuſpides tum obtuſiuſculas, nec niſi 0′ 13″ diſtabat à Boreâ, 8ʰ 41′ 00″ jam Cuſpidem illam reliquerat 3′ 42″. Et 8ʰ 45′ 37″ ab eadem diſtabat 5′ 36″. Lunæ diameter ad 8ʰ 58′ capta eſt 31′ 7″.

A Collection *of* Aſtronomical *Obſervations for* 1719, *by* — n. 263. p. 1109. —*of the* Planets.

† *Vid.* Infra §. XLI.

XXXIX. Nuperæ quas habemus Obſervationes hæ ſunt:

1718. *October* 10°. mane, applicabatur *Jupiter* ad Fixas Teleſcopicas, quarum loca, occaſione primæ apparitionis Cometæ anni 1680, (de quâ vide † *Phil. Tranſ.* N° 342.) ſedulo inquiſivit Rev. D. *Pound*, ac nuper verificata nobiſcum communicavit, una cum accuratâ obſervatione tranſitûs Jovis juxta eas hac vice, ac deinde alterâ *Febr.* 11°. ſtatim ab oppoſitione Solis & Jovis. Ineunte autem *Januario* 1719. loca ſtellarum ſic ſe habuere.

	Long.	Lat. Bor.
d ♌	29°. 59′. 43″	1 . 7 . 50
e ♍	0 . 6 . 13	1 . 10 . 18
c ♍	0 . 3 . 13	0 . 32 . 50
a ♍	0 . 25 . 41	1 . 28 . 54
x ♍	0 . 5 . 43	0 . 51 . 56

Ubi notandum ſtellas *d* & *e* eandem præciſè hoc ſæculo ſortiri declinationem, *x* vero exiguam eſſe ſtellulam in priore deſcriptione ob parvitatem omiſſam.

Jam *Octob.* 9°. 17ʰ 50′ T. æq. Jovis limbus orientalis attigit lineam ſtellas *e* & *c* jungentem, ſimul centrum ejus diſtabat ab *e* 21′ . 20″ & à *c* 16′ . 25″. ſtatimque aberat à *d* 19′ . 35″. Parvula *x* Jovi proxima latuit, luce ejus obumbrata.

Decemb. 11°, 18ʰ. 30′. T. æq. *Saturni* centrum diſtabat à *μ Libræ Bayero*, 28′ . 32″, & Fixâ borealius erat 4′ . 31″. Hinc concluſit D. *Pound* Obſervator *Saturni* locum ♎ 1° . 41′ . 10″, cum Lat. bor. 2° . 16′ . 43″.

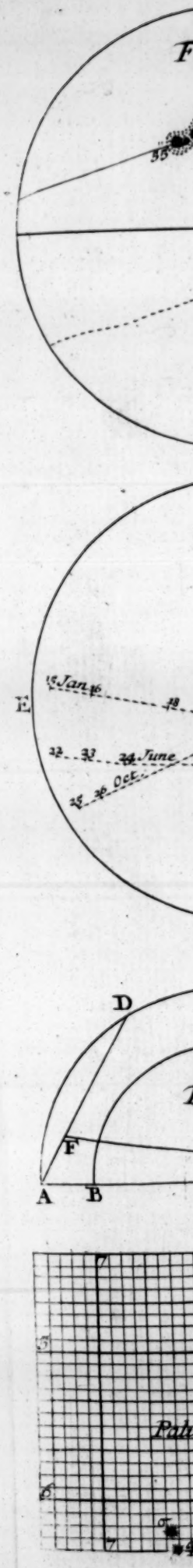


Fig. 113.

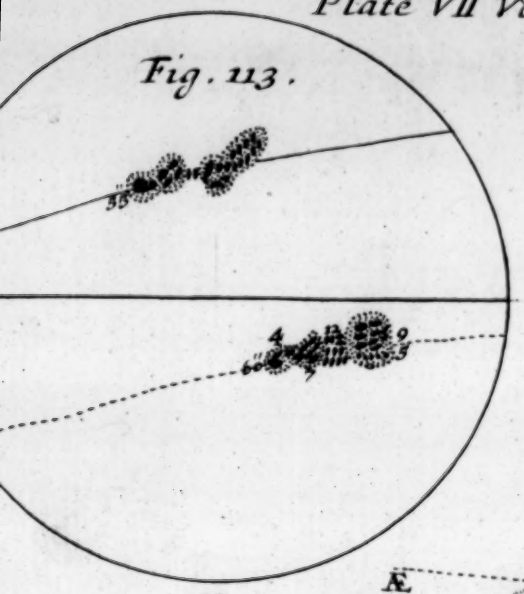


Fig. 114.

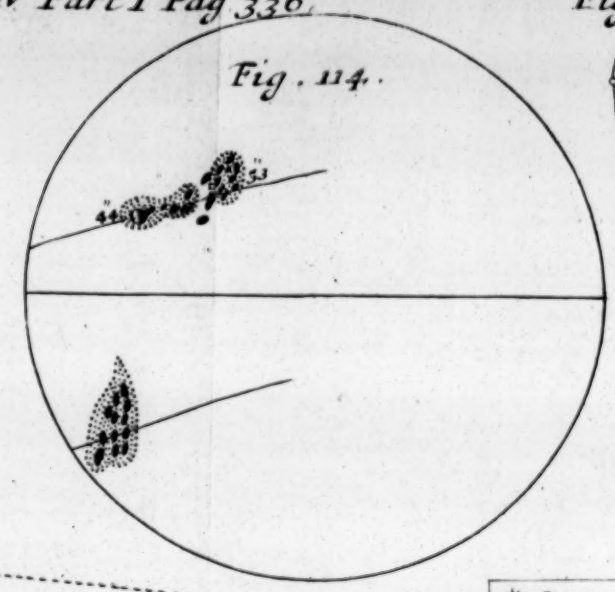
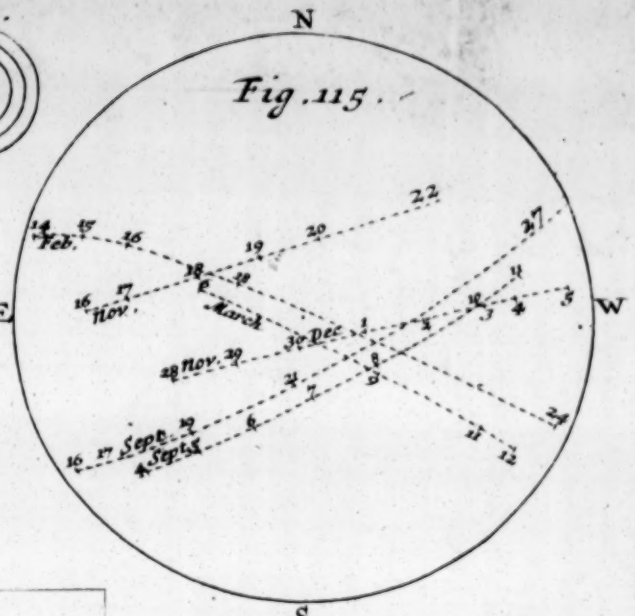


Fig. 118.

Fig. 115.



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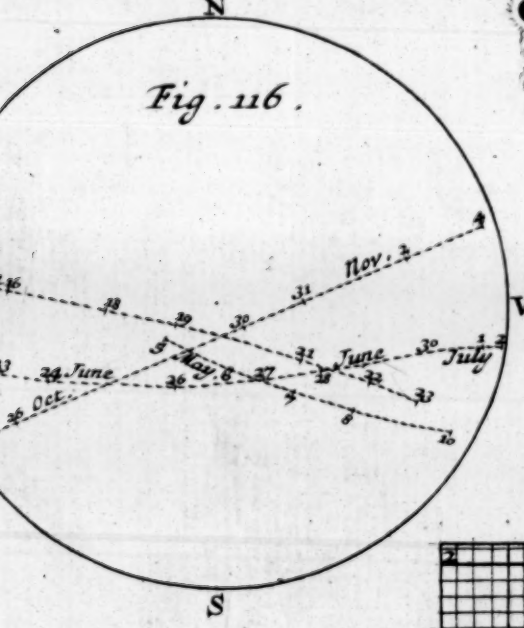
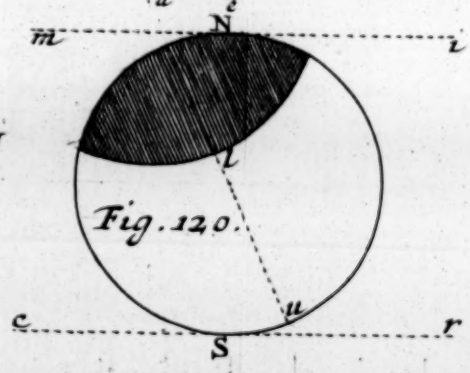


Fig. 117.

Fig. 120.



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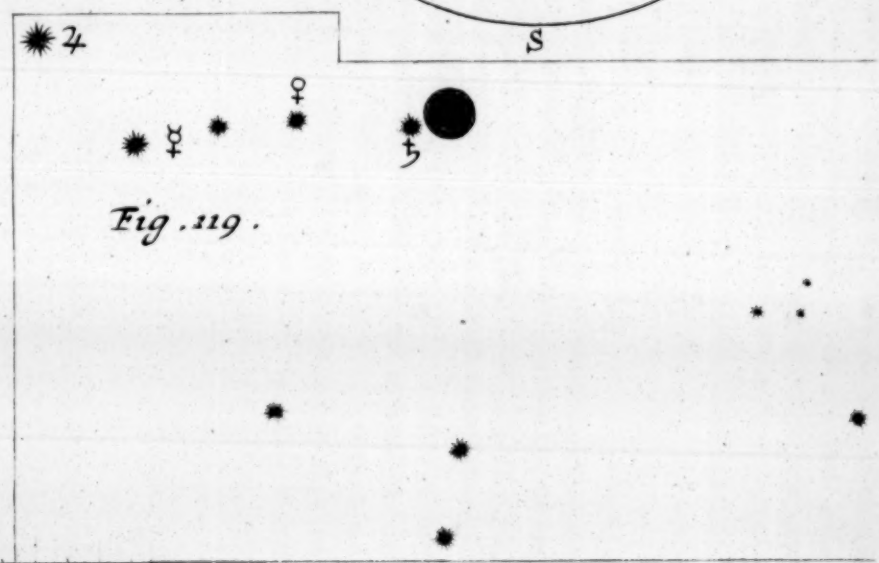


Fig. 123.

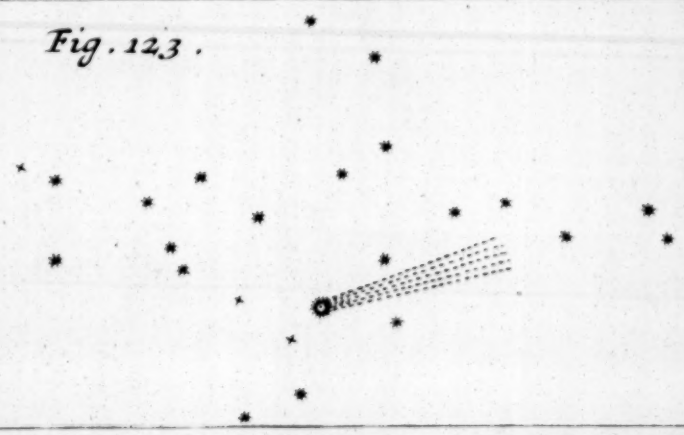


Fig. 124.

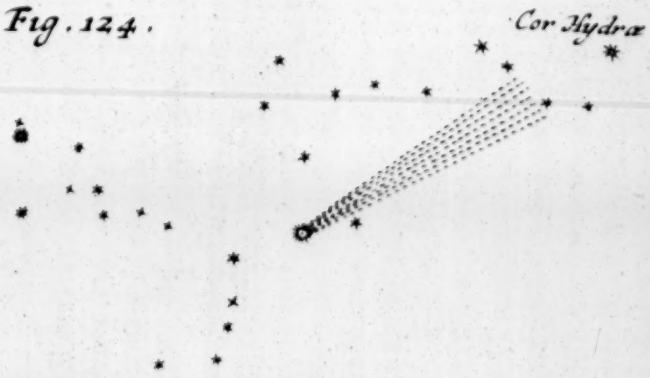
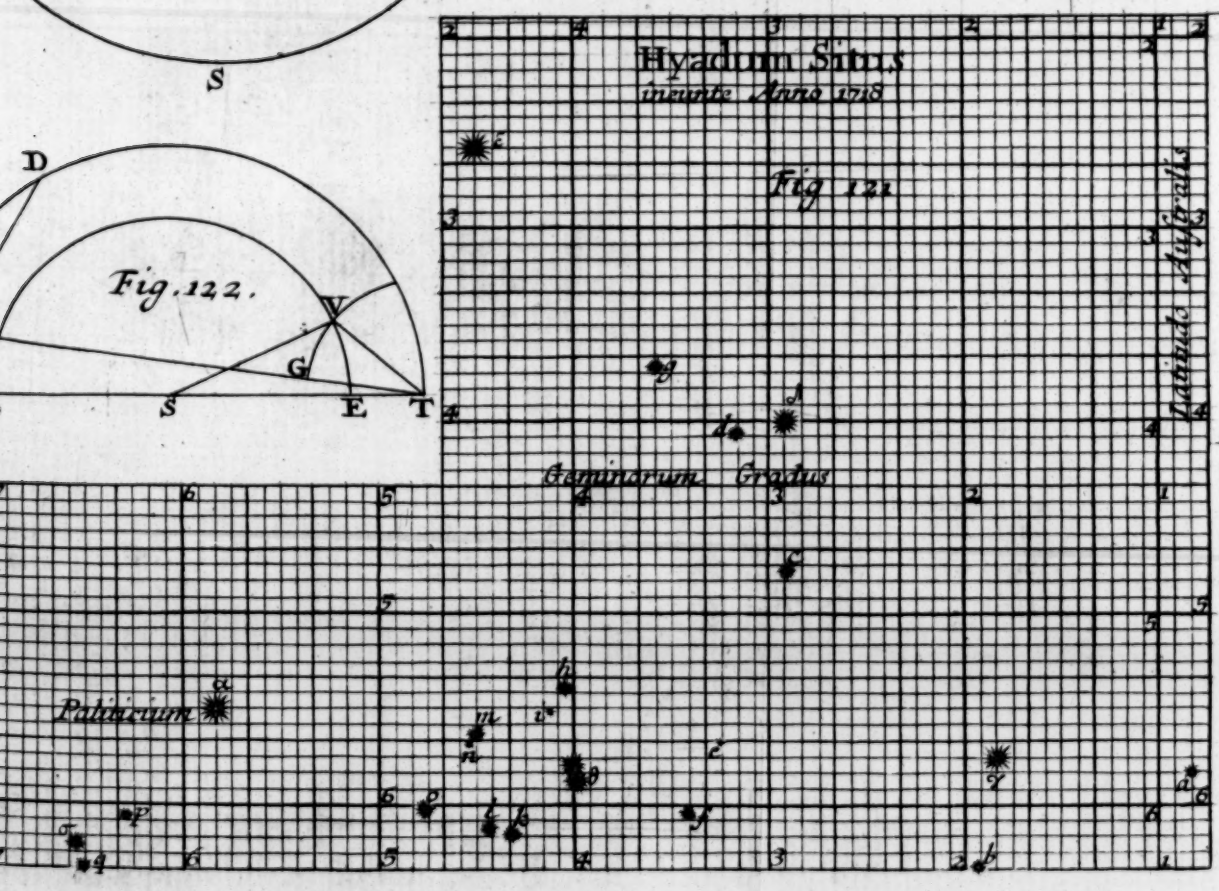


Fig. 122.

Fig. 121.



ginem attingerent. Stella vero quæ durante Eclipſi occultata eſt, locum tunc habuit ♓ 17° 16′½ cum Lat. auſt. 1° 6′ 30″ proximè.

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Denique Coronidis loco Obſervationem adjiciamus, eximiam, quidem, ſuique generis, quod ſcimus, ab invento Teleſcopio primam; quamque indefeſſæ D. *Jac. Bradley* debemus diligentiæ. Quinto enim *Septembris* manè, Sole jam fere 30 gr. alto, vidit apud *Wanſted* arctiſſimum Lunæ infra *Palilicium* tranſitum, cujus diſtantiam à limbo proximo, ad 7h 59′ 00″ T. æq. Micrometro invenit 5′ 38″. Ad 8h 17′ 5″ diſtabat à limbo 1′ 25″. Stella autem ad 8h 33′ 15″ erat in linea recta per Lunæ Cuſpides tum obtuſiuſculas, nec niſi 0′ 13″ diſtabat à Boreâ, 8h 41′ 00″ jam Cuſpidem illam reliquerat 3′ 42″. Et 8h 45′ 37″ ab eadem diſtabat 5′ 36″. Lunæ diameter ad 8h 58′ capta eſt 31′ 7″.

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	Long.	Lat. Bor.
d ♌	29°. 59′. 43″	1 . 7 . 50
e ♍	0 . 6 . 13	1 . 10 . 18
c ♍	0 . 3 . 13	0 . 32 . 50
a ♍	0 . 25 . 41	1 . 28 . 54
x ♍	0 . 5 . 43	0 . 51 . 56

Ubi notandum ſtellas *d* & *e* eandem præcisè hoc ſæculo fortiri declinationem, *x* vero exiguam eſſe ſtellulam in priore deſcriptione ob parvitatem omiſſam.

Jam *Octob.* 9°. 17h 50′ T. æq. Jovis limbus orientalis attigit lineam ſtellas *e* & *c* jungentem, ſimul centrum ejus diſtabat ab *e* 21′ . 20″ & à *c* 16′ . 25″. ſtatimque aberat à *d* 19′ . 35″. Parvula *x* Jovi proxima latuit, luce ejus obumbrata.

Decemb. 11°. 18h. 30′. T. æq. *Saturni* centrum diſtabat à *μ Libræ Bayero*, 28′ . 32″, & Fixâ borealius erat 4′ . 31″. Hinc concluſit D. *Pound* Obſervator *Saturni* locum ♎ 1° . 41′ . 10″, cum Lat. bor. 2° . 16′ . 43″.

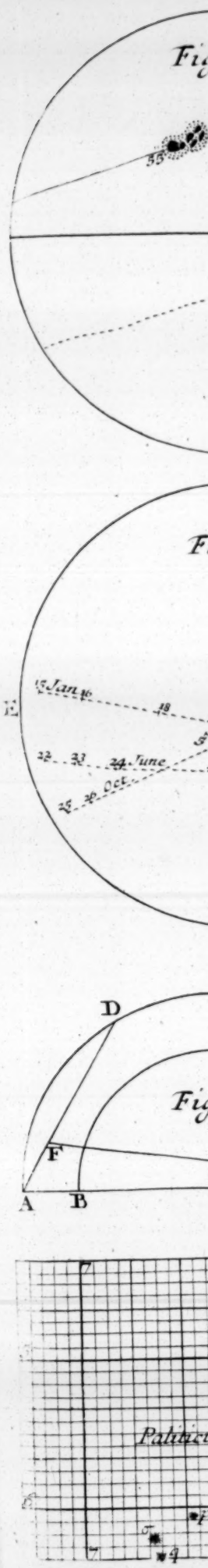


Fig. 113.

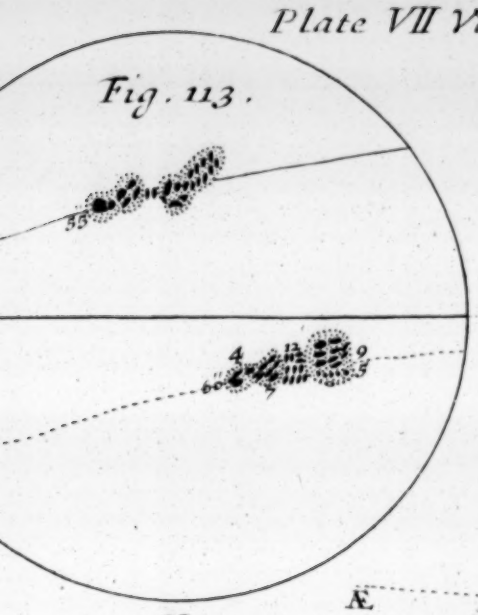


Fig. 114.

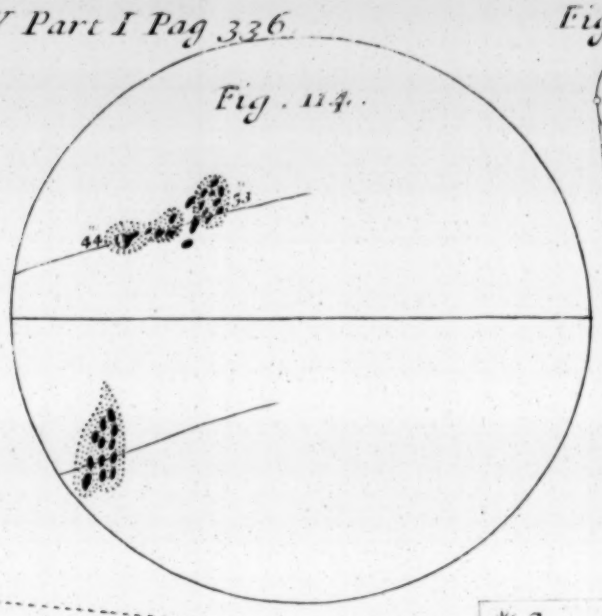


Fig. 118.

Fig. 115.

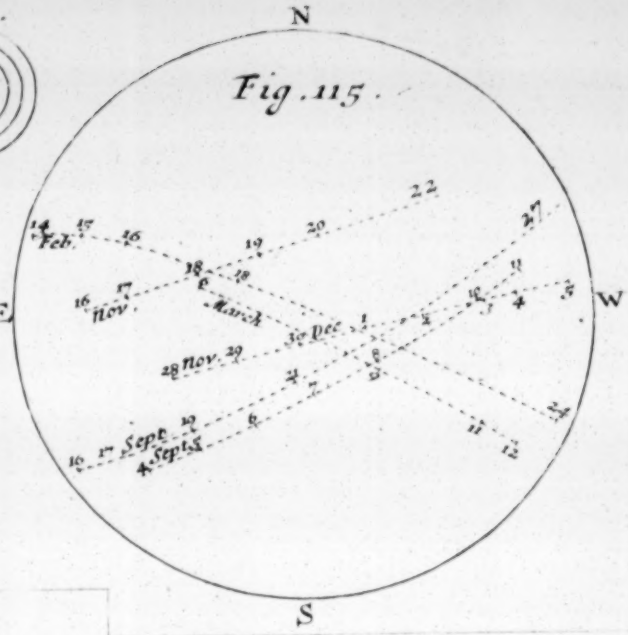
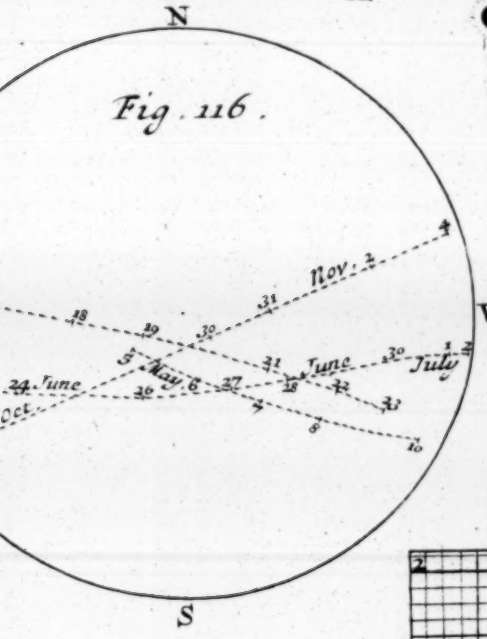


Fig. 116.



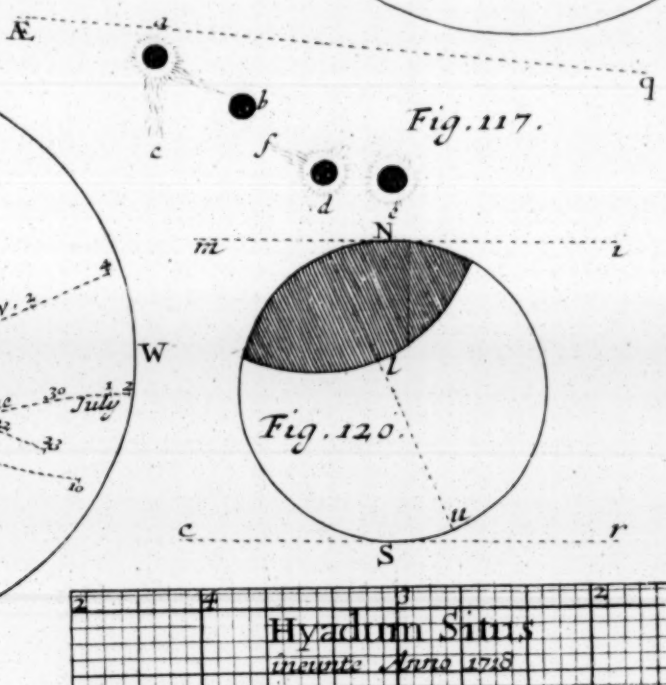


Fig. 117.

Fig. 120.

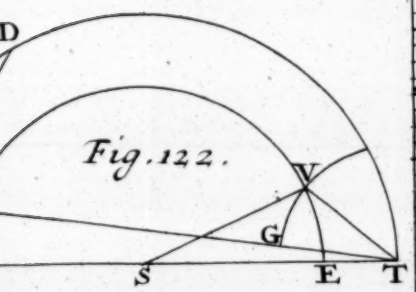


Fig. 122.

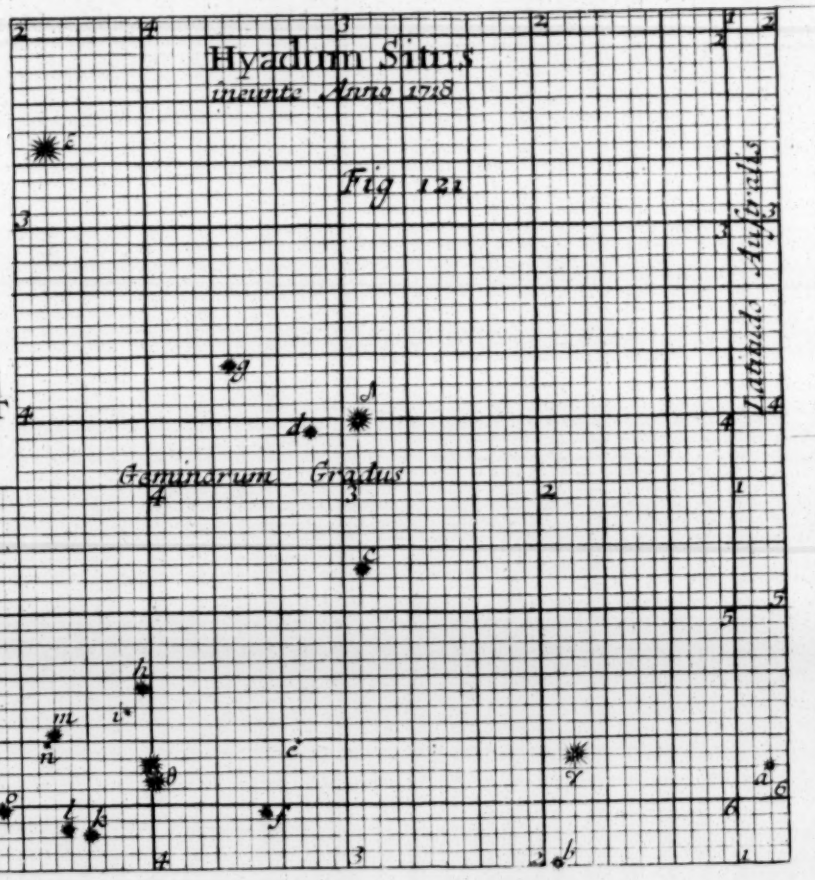


Fig. 119.

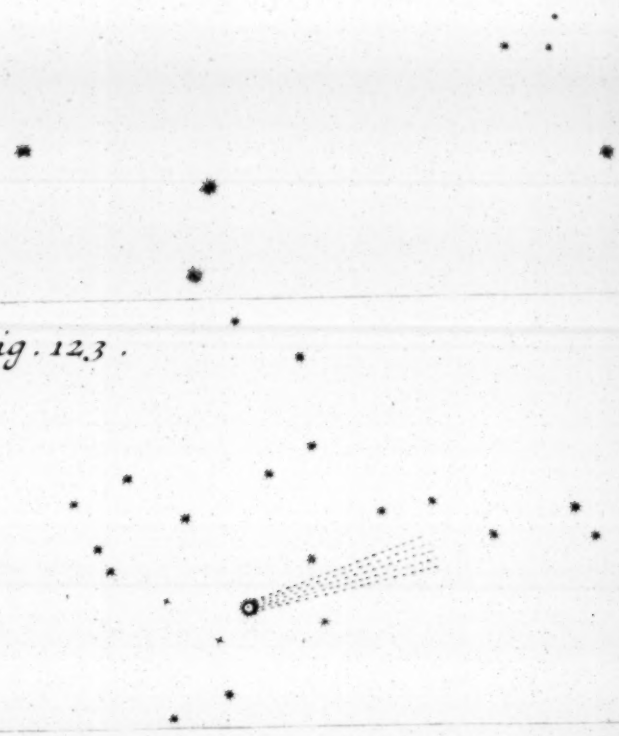


Fig. 123.

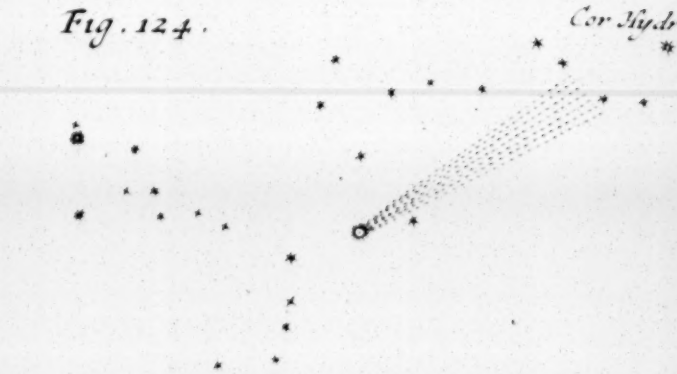


Fig. 124.

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1719. *Feb.* 11°. 6ʰ. 56′½ T. æq. *Jovis* retrogradi centrum diſtabat à ſtella *d* ſuperius deſcriptâ —— —— —— 10′. 42″
6 . 58¼ Idem centrum diſtabat ab *e* —— —— 6 . 7
9 . 37⅓ Iterum diſtantia capta à *d* —— —— 10 . 9
9 . 43½ Iterum ab *e* —— —— —— 6 . 11
9 . 49½ Jovis centrum diſtabat ab *a* —— —— 25 . 21
9 . 58½ Idem centrum à parvula *x* —— —— 24 . 38

Circa Horam ſeptimam *Jovis* limbus orientalis attigit lineam per *x* & *e* productam; *Jupiter* itaque tunc habuit ♍ 0°. 6 cum Latitudine boreal. 1° . 16′. 30″. Deinde,

Feb. 13°. 8ʰ. 0′. T. æq. Declinatio centri Jovis, Micrometro menſurata, borealior erat eâ ſtellæ utriuſque *d* & *e* 11′. 37″, & 8ʰ. 20′ eadem differentia inventa eſt 11′. 36″. Horâ vero 8ʰ. 48′ centrum Jovis diſtabat ab *e* 17′. 40″.

Apr. 22°. 10ʰ. 45′. T. æq. *Saturni* centrum ſequebatur *μ Libræ* 4′½ Temp. ſive 1′. 8″ Aſc. rectæ. Micrometro menſurata, borealior inventus eſt fixâ 35′. 25″. Stella autem in *Catalogo Britannico* tunc habuit, ♎ 10°. 16′. 8″. Lat. bor. 2°. 3′. 54″.

Maii 19°. 8ʰ. 00′ T. æq. ♃ ſequebatur *Cor Leonis* 1°. 34′½ Aſcenſionis rectæ; Borealior autem erat ſtellâ illâ 0′. 41″½. Temporis hoc eſt, 10′. 7″ Arcus cœleſtis.

Eâdem nocte, 15ʰ. 18′ T. app. obſervavit D. *Stephanus Grey Martem*, ratione Aſcenſionis rectæ, ſequi ſtellam *in Caud Capricorni* orientalem 16′. 15″; ſimul non niſi 0′. 11″. auſtralior erat quam Fixa.

Junii 7°. 10ʰ. 15′. T. app. *Jupiter* directus iterum reverſus eſt ad ſtellas Teleſcopicas prædictas, & tum ſequebatur ſtellam *d*. 0′ 35″ Aſcenſionis rectæ, & 10ʰ. 30′ diſtabat Fixa â limbo *Jovis* proximo 4′. 18″.

Poſtridie *Junii* 8°. 10ʰ. 20′, *Jupiter* ſequebatur ſtellam alteram *e* 1′. 30″ Aſcenſionis rectæ, ac ſtatim diſtantia limbi *Jovis* proximi à ſtella capta eſt Micrometro 7′. 30″.

Julii 5. 8ʰ. 26′. T. app. conjungebantur arctè *Jupiter* & *Venus*, quæ tum borealior præcedebat *Jovem* ſecundum Aſcenſionem rectam 1′. 20″: Centrorum autem diſtantia ex decies repetitis media, capta eſt 13′. 36″. Hæc tria *Londini* obſervata communicavit harum Scientiarum eximius Cultor D. *Martinus Folkes*.

Aug. 3. 12ʰ. 20′ T. æq. *Mars* pene Acronychus ſequebatur ſtellam τ *Aquarii Bayero* 10′. 58″ Temporis, ſive 2°. 44′. 57″ Aſcenſionis rectæ. Erat autem Fixâ *Mars* borealior 0′. 36″ tantum; unde conceſſo loco ſtellæ *Britannico* fit locus *Martis* obſarvatus ♓ 7°. 10′. 10″ cum Latitudine auſtrali 6°. 38′. 10″.

Aug. 10°. 11ʰ. 50′. T. æq. *Mars* ſequebatur Fixam minorem quæ præcedit τ *Aquarii* 1°. 39′. 30″ ratione Aſcenſionis rectæ; auſtralior vero quam Fixa 10′. 42″.

Aug. 16°. 7ʰ. 18′. T. æq. *Spica Virginis* præcedebat *Veneris* centrum 5″ ¼ ſecundis temporis, ſive 1′. 20″ Aſcenſionis rectæ, auſtralior Planetâ 18″ ¼ temp. ſive 4′, 35″.

Aug. 17°. *Mars* pridie Achronychus ac Terris proximus obſervatus ad duas ſtellulas contiguas, Parallaxis ejus inveſtigandi gratiâ, juxta methodum à D. *Caſſino*, in libro de Cometa anni 1680, exhibitam, Unde *Martis* Parallaxin eruere in *Tranſact.* proximâ conabimur. Harum vero ſtellularum Borea tum temporis locum habuit ♓ 3°. 5′. 50″ cum Latitudine auſtrali 6°. 6′ ¼ altera vero auſtralior habuit ♓ 3°. 5′. 30″, cum Lat. auſt. 6°. 10′ ¼ proximè. Horâ vero 10ʰ 40′. T. æq. auſtralem ſequebatur *Mars* 41′ min. 40″. Aſcenſionis rectæ, eâque adhuc auſtrâlior erat 7′. 50″.

Sept. 18. 9ʰ. 20′. T. æq. *Mars* viſus eſt præcedere ſtellam in *Catalogo Britannico* Aquarii 33ⁱᵃᵐ. 3′. 45″ Temporis, ſive 56′. 24″. Aſcen. Rectæ; ſimulque Stella borealior erat limbo Martis boreo, non niſi unâ Planetæ diametro. Locus ſtellæ ♒ 29′ 57″ ½ Lat. auſt. 4°. 48 ½.

Octob. 30. Veſperi 5ʰ. 45′. T. app. *Mars* proximus ſtellis duabus contiguis ad *h* ♒ *Bayero*, quæ ſunt ♒ 73ⁱᵃ & 74ᵗᵃ *Catal. Brit.* Præterierat rectam per eaſdem ductam, eratque angulus ad *Martis* centrum ad ſenſum rectus: Borea vero ſtellarum eandem habuit declinationem cum limbo Planetæ auſtrino. 5ʰ 53′ diſtantia ſtellæ à centro *Martis* 2′. 30″ 5ʰ. 56′ centrum *Martis* diſtabat à tertiâ & auſtraliore ad *h*, ſive 75ᵗâ Aquarii, 17′ 04″. 6ʰ. 18′ diſtant centri à Boreâ ſive 73ᵗâ erat 3′. 5″. Hinc concludere licet *Martem*, horâ 3ʰ. 30′ proximè, ſtellæ boreæ conjunctum fuiſſe, eamque uno tantum minuto ad Boream reliquiſſe. Fixæ autem locus è *Catalogo Britannico* tunc erat ♓ 10°. 29′. 00″ cum Lat. auſt. 1°. 40′ ¼. 74ᵗᵃ vero habuit ♓ 10°. 29′. 50″ cum Lat. auſt. 1° 44′ ¼.

Novemb. 16°. 19ʰ. 18′. T. æq. *Venus* præcedebat *Lancem Libræ* auſtrinam 3′. 13″ Tem. ſive 48′. 23″ Aſcen. Rect. ſimulque fixâ borealius erat centrum *Veneris* 7′. 45. *Venus* quaſi Stationaria apud Nodum ejus Aſcendentem.

Decemb. 3°. 19ʰ. T. æq. *Saturnus* præcedebat tertiam ad ζ *Libræ* ſive *Libræ* 29ᵃᵐ. *Cat. Brit.* 0′. 46″ Temp. ſive 11′. 32″. Aſc. Rect. Erat autem fixâ auſtralior 15. 29″. differentiâ per Micrometrum captâ. Unde Saturnni locus ♏ 20. 25 ½ cum Lat. Bor. 2°. 5′ ¼.

—*of the* Moon *and* Eclipſes.

Obſervationem ſupra † dedimus Eclipſeos Lunaris anno 1717 *Martii* 15° P. M. St. vet. apud *Cambridge Nov-Anglorum* habitam; apud nos vero ob Nubes inconſpicuam. Defiit autem Eclipſis ibidem 11ʰ 42′ ½ neque alia ejus tum temporis ſuppetebat obſervatio. Poſtea vero Dom. *Candler* Navarcha Regius, ex *America* attulit & nobiſcum communicavit ejuſdem Eclipſeos phaſes *Limæ Peruviæ* à *Dom. Petro Peralta*, Mathematico Regio obſervatas, Typiſque ibidem impreſſas. Initium autem Eclipſeos ponit *Limæ* 8ʰ. 41′. 8″. Finem vero 11ʰ. 19′. 55″. Simul laudatus D. *Candler* propriam obſervationem, ad Inſulam quam

† *Vid.* Super. p. 332.

Virgine Gorda vocant captam, conceſſit, Ibi deſiit Eclipſis $12^h. 13'$. P. M. Fine per cœlum ſudum diſtinctè viſo. Inter Acta Regiæ Scientiarum Academiæ *Pariſienſis* iſtius anni, comperimus etiam duas & quidem ſatis conformes hujus Eclipſeos Obſervationes, alteram à D. *Caſſino*, alteram à D. *de la Hire* in Obſervatorio Regio captas: Hic Initium æſtimavit $13^h. 54'$. Finem vero certius $16^h. 38'. 10''$. At ille Initium $13^h. 55'$ & Finem $16^h. 38' 25''$. Maxima obſcuratio huic $7\frac{1}{3}$ Dig. illi $7\frac{1}{2}$ Dig.

Hinc ex Fine, in ſingulis locis ut videtur accuratius ſumpto, proveniunt Longitudinum differentiæ inter *Pariſios Limam* $5^h. 18'. 20''$, Inter *Pariſios* & *Cambridge* $4^h. 55'. 50''$. Inter *Pariſios* & Inſulam *Virgine Gorda* $4^h. 25' 20''$. E quibus ſi $9'. 40''$ ſubduxeris, provenient Longitudines ad occaſum *Londini*, nempe *Limæ* $77°. 10'$. *Cambridge Nov. Anglorum* $71°\frac{1}{2}$, ac denique Inſulæ *Virgine Gorda* $63°. 55'$; unde Inſularum adjacentium ſitus Geographici certo corrigi poterint.

Altera Lunæ Eclipſis ejuſdem anni *Septembris* nono Veſperi, ab iiſdem obſervatoribus & D. *Maraldo Pariſiis* conſpecta eſt. Finem *Londini* obſervavimus in ædibus Societatis Regiæ $7^h. 26'$. *Pariſiis* vero D. *Caſſino* Finis $7^h. 34'. 50''$, D. *Maraldo* $7^h. 35' 30''$, & D^{no} *De la Hire* $7^h. 34'. 15''$. Simul D. *Wurtzelbaur Noribergæ* eundem Finem vidit $8^h. 10'. 45''$. Hinc confirmantur Meridianorum differentiæ *Londinum* inter & *Pariſios*, præſertim ex obſervatione D. *Maraldi*, nempe $9'. 30''$; uti & inter *Londinum* & *Noribergam* $44'. 45''$, quantam ſæpius olim experti ſumus. Porro quinto die poſt Eclipſin, *Septembris* 14^{to} veſperi, Luna ocultavit *Palilicium Pariſiis*, obſervantibus ſigillatim DD. *Maraldo* & *Deliſle* Juniore. Evanuit autem ſtella è regione Maculæ *Grimaldi* ſive *Paludis Mareotidis*, Hora $9^h. 11'. 35''$. Emerſit autem è limbo Lunæ obſcuro $10^h. 3'. 55''$. Hujus Occultationis Obſervationem *Londini* † ſupra dedimus. † *Vid.* Supra p. 332.

Obſervationes illas, in quibus Temp. æq. *adhibetur, Rev. D^{no}* Pound *acceptas debemus. Tubo autem quindecimpedali captæ pro certiſſimis habendæ ſunt.*

XL. *December* the 20^{th} 1664. N. S. about three of the Clock this Morning, I obſerved the *Comet*; it was in the Conſtellation of *Hydra*, not far from the Foot of *Crater*. It appeared about the Bigneſs of a Star of the firſt Magnitude, but nothing ſo lucid and bright. It had a very long Tail, which pointed almoſt directly towards the Heart of *Hydra:* The Tail ſhewed ſomewhat like Rays of a Candle burning in a Miſt: The Figure of it was Conical; the Length of it 5 or 6 Degrees; the Breadth at the Baſe not above a Degree and an half. The Body of this *Comet* was about 3 Degrees to the South-Eaſt of the moſt Southerly Star in the Foot of *Crater*; it ſtood very near in a Right Line with the two lowermoſt Stars in the Foot of *Crater*, which are common to it and *Hydra*. Fig. 123.

Obſervations *at* Rome *on the* Comet 1664. *by the late Mr.* J. Ray, *communicated by Mr.* S. Dale, n. 309. p. 2350.

December 21. In the Morning, about the ſame Hour, it was removed about a Degree and an half from the Place where it ſtood, Weſtward, and a little to the South. The Tail pointed ſtill towards the Heart of
Fig. 124. *Hydra*, and appeared 10 Degrees long at the leaſt.

December 22. At the ſame time it was removed from the Place where it ſtood the Day before, to the ſame Point, and about the ſame Diſtance
ig. 125. as the Night before. The Tail of it ſtill pointed to *Cor Hydræ*, or a little thought above it, as the two former Days, and was rather longer than ſhorter: It alſo, to my thinking, appeared brighter and larger; the Body of it being bigger than any fixt Star, except *Sirius*.

December 23. It was removed to the ſame Point, and about the ſame
Fig. 126. Diſtance as the Day before; the Tail of it was as long as ever, and the *Comet* brighter. The Tail pointed almoſt directly to *Cor Hydræ*.

December 24, 25, 26. All theſe three Nights were cloudy, ſo that I could make no Obſervations.

December 27. We found it ſtrangely removed from the Place where it was: It was ſtill Weſtward, and a little to the South, as before. The
Fig. 127. Body of the Star was ſtill brighter, and the *Cauda* about it greater, and more buſhy, and yet as long as before; it pointed almoſt directly againſt *Canis major*. The Body of it was amongſt the Stars of *Argo*.

December 28. The ſame time it was removed above two Degrees towards the ſame Point, and come within four or five Degrees of the moſt Eaſtern Stars in the bright Triangle in the Buttocks of *Canis major*.
Fig. 128. The *Moon* ſhining, we could not ſo well judge, either of the Bigneſs of the Body, or the Length and Buſhineſs of the Tail.

December 29. It was ſtrangely removed, and got before, not the Eaſtern Star only of the mentioned bright *Triangle*, but alſo the moſt Northern. I think, at leaſt, in this laſt twenty four Hours, it had
Fig. 129. moved four Degrees. The *Moon* ſhining bright, the Tail could not well be obſerved, yet ſtill it ſeemed to point directly to *Canis minor*.

Obſervations *on the* Comet 1680. *ſeen in* Saxony *by Mr.* G. Kirch, *by* — n. 342. p. 170.

XLI. Cometa ille, qui anno exeunte 1680. viſus eſt, plurimis de cauſis præcipuus merito habendus eſt; tam ob Curſum ejus quadrimeſtrem, quo novem integra Signa percurrit; quam ob immenſam Caudæ magnitudinem & claritatem: maxime vero ob inſignem Orbitæ Curvitatem, cujus ope tandem patefacta eſt Cometarum Theoria, per Clariſſ. D. *Newtonum*, qui primus mortalium Cometas Orbes Parabolicis maxime affines deſcribere probavit.

Accidit

Accidit autem, neſcio quo fato, ut Cometa hic (quem veſpertinum tantopere proſecuti ſunt Cœliſpices) antequam Solem attigerat matutinus, nec *Pariſiis* neque *Grenovici* ne ſemel quidem obſervatus ſit: quique eum viderunt & obſervarunt, incongrua & inter ſe pugnantia, ac pro rei ſubtilitate parum idonea prodidere: neque ante *Novembr.* 17. mane a quopiam Obſervatorum viſus eſt. Unde factum ut Orbitæ pars illa, qua ad Solem deſcendit Cometa, paulo incertius definiri potuit. Nuper autem incidimus in Librum meritiſſimi Aſtronomi Domini *Gottfried. Kirch. Germani*, anno 1681. *Noribergæ* impreſſi, cui titulus **Neue Himmels zeitung**, hoc eſt *Novus Nuncius cæleſtis*; ubi auctor diligentiſſimus nobis exponit, quo caſu ductus Cometam hunc, nondum adnata Cauda obſcurum, ac vix nudis oculis conſpicuum detexerit; dum ſcilicet Lunam & Martem ei vicinum obſervaturiens circumluſtraret, die *Novemb.* 4. *S. V.* mane, idque *Coburgi Saxoniæ*, quod oppidum XI. Grad. *Londino* orientalius eſt, ſub altitudine poli 50° 20′ circiter. Excitatus autem, ut ait, rumoribus Cometæ in *Germania* viſi, vultu in Orientem verſo pernoctavit, ut cœlo tum forte perquam ſereno, ſi quid novi oriretur, ſitum ejus notaret. Lunâ vero jam ad ſtellam aliquam *Tychoni* incognitam applicatâ, (ſed quæ in Catalogo *Flamſteedii Britannico* habetur, eſtque numero 44ta *Leonis)* voluit dictæ ſtellæ locum ex circumvicinis Fixis determinare; dumque Tubum trium graduum capacem hinc inde circumrotat, incidit in Luculam quandam nebuloſam, ſpeciem inſolitam præ ſe ferentem, quamque vel novum Cometam eſſe, vel Stellam nebuloſam ad inſtar ejus quæ in *Cingulo Andromedæ* eſt, ſtatim concluſit.

Primo autem Cometam vidit, Hora $4\frac{1}{2}$ matutina, paulo altiorem duabus ſtellulis Teleſcopicis, quæ literis *a* & *o* ſignantur, cum quibus tamen Hora 6ta viſus eſt in linea accurate recta; unde conſtabat eum moveri, idque motu directo. Inter horas vero 5 & 6. Tubo decempedali Phænomenon hoc contemplatus eſt, viditque duas alias ſtellulas contiguas, prioribus minores, literiſque *e* & *d* notatas, & ſupra has tertiam *g*. Erat autem diſtantia Cometæ ab *e* paulo minor quam ab *a*, major vero diſtantia *d e*. 6h. 38′ diſtantia Cometæ ab *e* dupla erat intervalli inter ipſas *d e*, ac linea *d e* producta reliquit Cometam * infra ſe, ſic tamen ut marginem ejus ſuperiorem attingeret, 6h. 45′. Cometa jam ſenſibiliter remotior erat ab *e* quam ab *a*, diſtabatque ab *a* paulo plus quam dimidio diſtantiæ ſtellularum *a* & *g*. Fig. 130.

Notandum vero eſt Horologium totis 14 minutis cœlum anticipaſſe, uti ex altitudinibus *Cordis Leonis* tum captis patuit.

Nobilis ſane eſt hæc obſervatio, adeoque Stellularum Cometæ tunc adjacentium loca non una methodo perquiſivimus, exercitatiſſimam manum ſuam & inſtrumenta perelegantia præbente D. *Jacobo Pound.* Unde conſtabat ſtellulas illas tum temporis infraſcriptos habuiſſe ſitus, nempe

* Tubo ſcilicet objecta invertente.

Long.

		Long.			*Lat.*			
a	♌	29°	54	20″	1	29	20	Bor.
b		29	27	20	1	8	00	
c		29	34	30	1	10	45	

Circulus autem maximus per *a* & *c* ductus, deprehenſus eſt per *Ultimam Caudæ Urſæ majoris* tranſire, adeoque angulum cum circulo Longitudinis ad *a* eſſe 15° 36′½. Cumque diſtantia Cometæ ab *a* verſus *c* paulo major fuerat dimidio diſtantiæ *a g*, (quam Tubo ſedecim pedum & Micrometro deprehendimus 21 ⅖ min.) ponamus eam fuiſſe duodecim minutorum; & ex datis proveniet Cometæ locus ♌ 29° 51′ cum Lat. Borea. 1° 17′¼. Hora ſcilicet Horologii 6ta, ſed *Londini* 5h 2′ Temp. Appar.

Deinde *Novemb.* 6. mane, 4h 42′, Tubo bipedali deprehendit Cometam omnino in linea recta inter *Martem* & Stellulam *N*; quæ quidem in *Catalogo Britannico* 45ta Leonis eſt, & tunc erat in ♍ 2° 42′ cum Lat. Auſt. 0°. 16′½. Mars autem tunc temporis habuit (ex collatis Obſervationibus antea & poſt factis) ♍ 3°. 46′½. cum Lat. Bor. 1° 56′. Unde, ob datam ejus viam, Cometa occupavit ♍ 3° 23′ cum Lat. Bor. 6′, *Londini* Temp. App. 3h 58′ mane.

Fig. 131. *Novembris* quoque 11mo 5h 15′ mane, Cometa æqualiter diſtabat à Stellis Leonis σ & τ *Bayero*, nondum vero attigit rectam eaſdem jungentem, ſed parum abfuit ab ea. In *Catalogo Britannico* σ tunc habuit ♍ 14° 15′. cum Lat. Bor. 1° 41′ ferè, τ vero ♍ 17° 3′½ cum Lat. Auſt. 0° 34′. Proinde Cometæ Latitudo paulo minor erat medio inter illas, nempe quam 0° 33′½ Bor. ac Longitudo quam ♍ 15° 39′. Sed huic non utique fidendum, cum pendeat ab æſtimata æqualitate diſtantiarum, quæ res lubrica eſt. Cauda autem jam cœpta non niſi dimidio gradu longa Tubo decempedali viſa eſt.

Qui plura cupit adeat Librum ipſum *Germanicè* editum.

Obſervations *on a* Comet *ſeen in* 1718. *at* Berlin, *by Mr.* G. Kirch, n. 357. p. 820.

XLII. Cl. *Chriſtiſridus Kirchius*, motus Corporum cœleſtium ſedulò obſervans, a. d. XV. Kal. Febr. *(Jan.* 18. *ſt. n.)* anni præſentis, veſperi dimidiâ Septima, verſus Septentriones fortuitò Cometam conſpexit. Vicinus erat ad dextram (ſtellarum) γ & β *Bayeri* in *Urſa minore*, nudoque oculo longè diſtinctus apparebat, quam β *Urſæ minoris*, licet ea inſignis ſit Stella ſecundæ magnitudinis, cum longè pallidior quidem majore tamen diametro, atque ſatis clara luce maxime circa centrum, conſpiceretur. Per Tubum viſus lucidam rotundamque referebat nubeculam; Caudæ autem nullum obſervari potuit veſtigium, neque Nucleus dignoſci. Motu celerrimo ab hora VII. ad XI. proceſſit, graduſque quatuor cum dimidio abſolvit, ut ex Obſervationibus colligitur.

Die 19no & 20mo *Januarii* cœlum nubibus fuit obductum. Die vero 21mo Cometa longè receſſerat à loco ſuo nupero, atque in *Caſſiopea* deprehendebatur, ubi cum ſtellis ε & δ triangulum conficiebat *(an æquicrure?)*

crure?) ſcil. Hora 5^h 45′ in 17° 34′ ♉, ſub Latitudine Boreali 49° 54′ hærebat: Deinde 9^h 15′, in 16° 38.′ ♉, ſub Lat. Bor. 49° 2′ conſpiciebatur. Cæterum multum decreverat, atque à celeritate ſua remiſerat; præterquam enim quod pallidior quam ante apparebat, ſtellas etiam quartæ dignitatis magnitudine haud ſuperare nudo oculo conſpectus videbatur, inque orbita ſua, quatuor cum dimidia horis, non ultra ſeſquigradum proceſſerat: Tubi autem beneficio diameter ejus 7 min. inveniebatur.

Jan. 23 hora IV mat. Cometa cum ♂ & φ *Caſſiopeæ* triangulum æquicrurum efficiebat, cum ab utraque 2° 41 ½ abeſſet. Hoc mane duarum horarum ſpatio vix dimidium gradum abſolvit; hora decima veſpertina cum ♂ *Caſſiopeæ* & φ *Perſei* in linea recta cernebatur, atque à priori 3° 38′, à poſteriori 3° 9′ diſtabat. Diameter ejus erat 5 min. nudoque oculo conſpectus ſtellam quintæ magnitudinis referat.

Die 24to *Jan.* hora VI. mat. nondum attigerat φ *Perſei*, ſed cum υ & g ejuſdem Aſteriſmi triangulum æquicrurum ſiſtebat, & ab utraque non planè 3 ½ grad. aberat. Plura ex Obſervationibus docebit Vir accuratiſſimus, in pleniori quam parat hujus Cometæ Hiſtoria.

Hactenus Nova Literaria *dicta* pag. 43, 44. *ubi deſiderantur Obſervationes Diei* 18va, *cum Cometa velociſſime motus terræ proximus erat, unde certius de Via ejus tam vera quam apparente judicium ferre poſſemus. Manifeſtum autem eſt eum Polo Æquatoris Boreo viciniſſimum die* Januarii 19no *tranſiiſſe. Quod ſi cui libeat has Obſervationes ad examen revocare, calculoque accurato ſubjicere; in illius gratiam, loca Stellarum fixarum quarum hic fit mentio, ex Catalogo* Britannico *excerpta, ſubnectuntur: Unde etiam patebit nonnulla in hac motus Cometæ deſcriptione haud ritè ſe habere; quæ tamen à Cl.* Kirchio *corrigi, in pleniori ejus quam promiſit hiſtoria, ſpes eſt.*

Stellarum fixarum Loca in eunte Anno 1718.

BAYERO		Long. °	′	″	Lat. Bor. °	′	″
Urſæ minoris	β	♌ 9	18	0	72	58	10
	γ	♌ 17	35	15	75	13	15
Caſſiopeæ	δ	♉ 14	00	35	46	23	25
	ε	♉ 20	50	8	47	31	50
	φ	♉ 11	36	35	45	4	5
Perſei	υ	♉ 8	32	0	35	23	45
	φ	♉ 10	41	35	36	49	15
	g	♉ 12	15	20	36	18	37

XLIII. That

A ſmall Teleſcopical Comet *ſeen* June 10. 1717. *by Dr.* E. Halley, n. 354. p. 721.

XLIII. That the Number of Comets is much greater than ſome, on Account of the late rareneſs of their Appearance, have ſuppoſed, may be collected from ſeveral ſmall ones, which have within few Years been deſcribed in the Memoirs of the *French* Royal Academy of Sciences; thoſe Obſervers aſſuring us, that they diſcovered one in *Sept.* 1698. another in *Feb.* 1699. a third in *April* 1702. and again a fourth in *Nov.* 1707. none of which, as far as I can learn, were ever ſeen in *England*; all of them having been very obſcure and without Tails, by Means whereof Comets uſually firſt ſhew themſelves. And beſides theſe, two other Comets with remarkably long Tails, the one in *Nov.* 1689. the other in *Feb.* 1702. paſt by unobſervable in theſe our Northern Climates, they having great Southing Latitude, and their Motions directed toward that Pole. Hence we may juſtly conclude, that the Returns of Comets are much more frequent than is vulgarly reckoned, and that it is only contingent, that for theſe 35 Years no one of them has been ſeen and obſerved by our Aſtronomers.

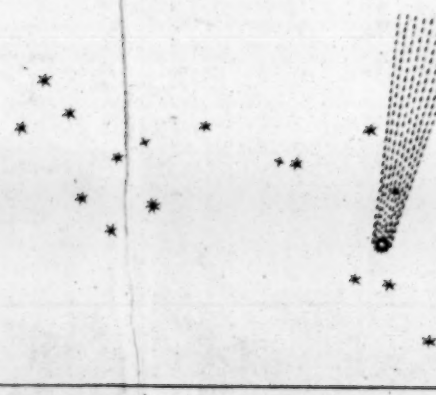
But there may be ſtill a much greater Number of theſe Bodies, which by reaſon of their Smallneſs and Diſtance are wholly inviſible to the naked Eye; ſo that unleſs Chance do direct the Teleſcope of an Obſerver, almoſt to the very Points where they are, it will not be poſſible for them to be diſcovered: And that this is not barely a Conjecture, take the following Inſtance.

On *Monday*, *June* 10. in the Evening, the Sky being ſerene and calm, directing my 24 Foot Teleſcope towards *Mars*, I accidentally fell upon a ſmall whitiſh Appearance near the Planet, reſembling in all reſpects ſuch a *Nebula* as I deſcribed in *Phil. Tranſ.* N°. 347. but ſmaller. It ſeemed to emit from its upper Part a very ſhort kind of Radiation directed towards the Eaſt, but Northerly withal; which, conſidering its Situation, was nearly towards the Point oppoſite to the Sun. The great Light of the Moon, then very near it, and alſo near full, hindered this *Phænomenon* from being more diſtinctly ſeen; but its Place in the Heavens was ſufficiently aſcertained from the Neighbourhood of *Mars*, from whom it was but about half a Degree diſtant towards the Southweſt, the Difference of Latitude being ſomewhat more than that of Longitude; and *Mars* being at time in ♐ 17°. 30′ with 3°. 48′ South Latitude. I concluded the Place thereof in ♐ 17°. 12′. with 4°. 12′. Lat. South, or thereabouts; the which may yet be more ſecurely determined by help of two ſmall fixt Stars I found near it, the more Northerly of which I judged to have the ſame Latitude with it, and to follow it at about the Diſtance of ſix Minutes; the other Star was about four Minutes more Southerly than the former, and about one Minute in conſequence thereof; the Angle at the Northern Star was a little obtuſe, as of about 100 Degrees, and the Diſtance of our *Nebula* from it *Seſqualter* to the Diſtance of the two Stars, or rather a little more. The Rev. Mr. *Williams*, Mr. *Thomas*, and myſelf, contemplated

Vid. Supr. p. 224.

Fig. 125.

Fig. 127.



Sirius

Fig. 129.

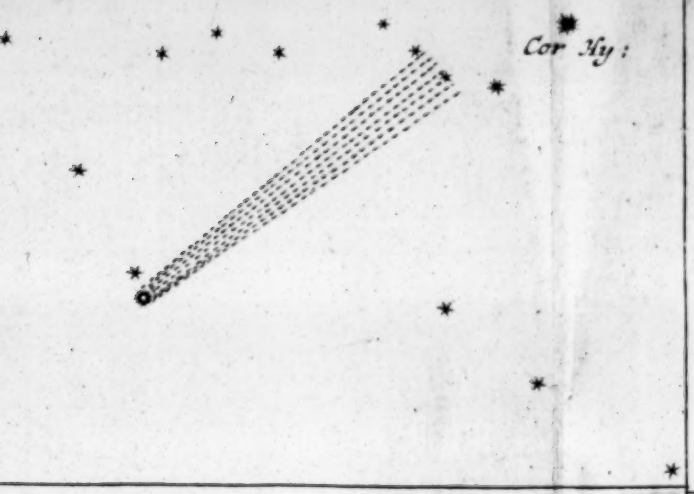
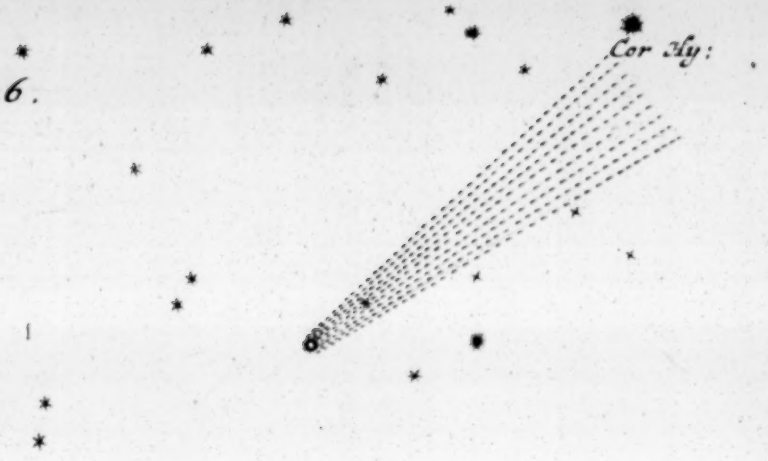
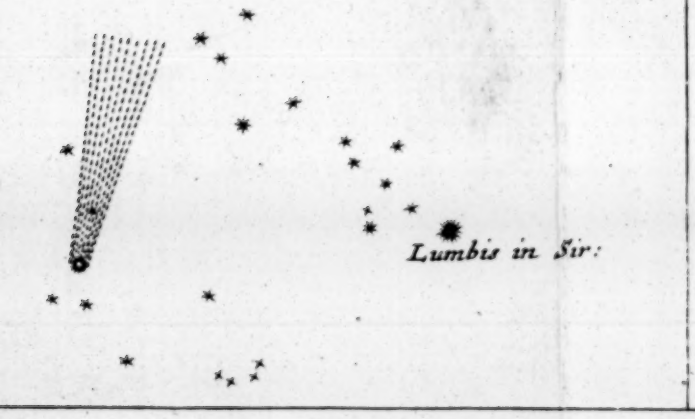


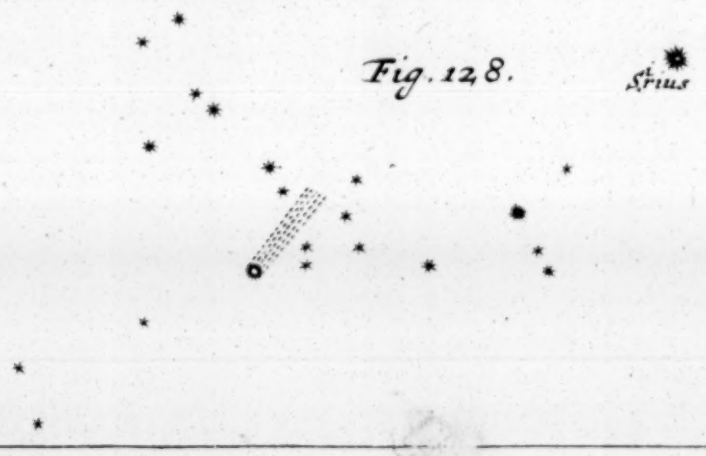
Fig. 126.





Hoc schema vero situi Stellaru: propius

Fig. 128.



Sirius

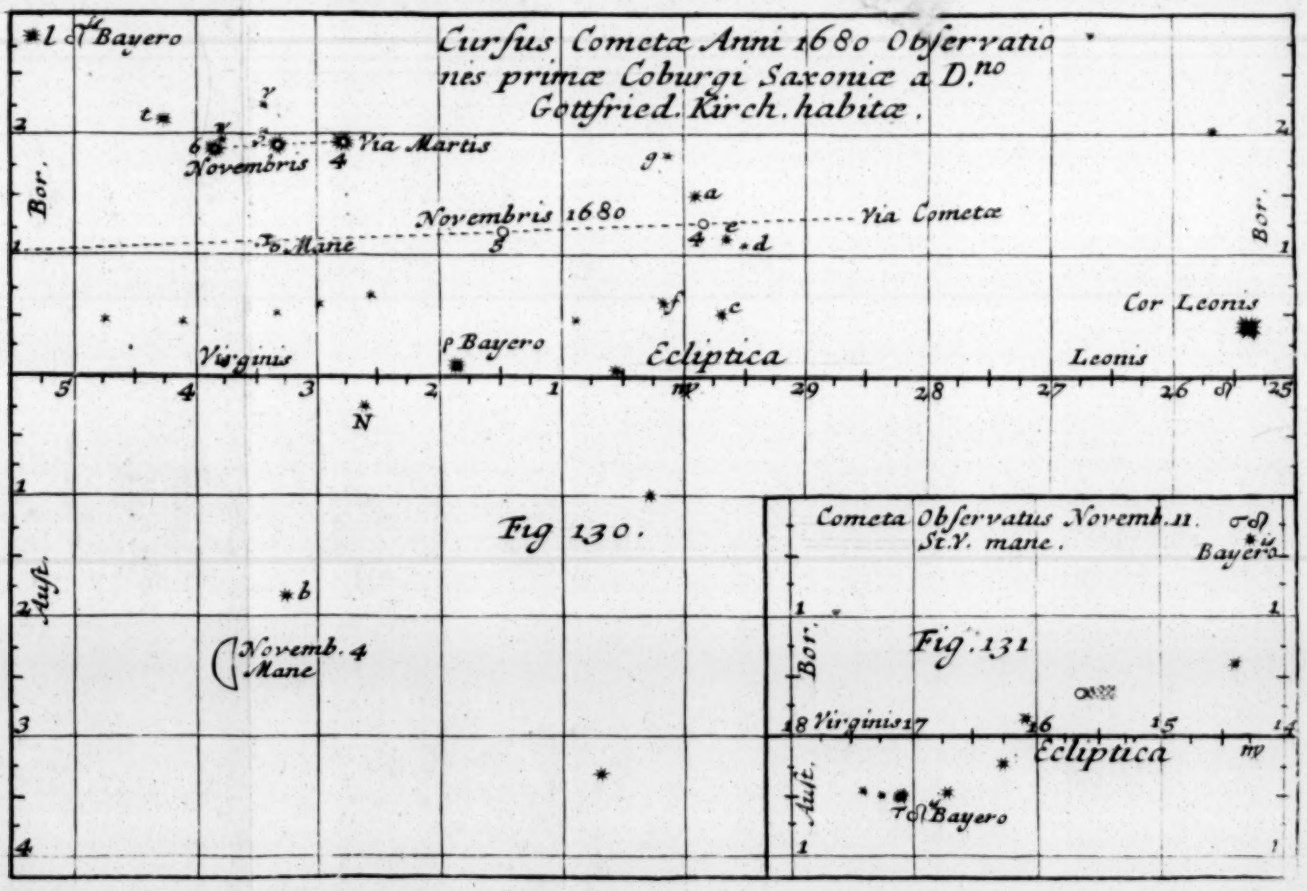


Fig 130.

Fig. 131

plated this Appearance for above an Hour, *viz.* from half an Hour paſt 10 to near 12, and we could not be deceived as to its Reality; but the Slowneſs of its Motion made us at that Time conclude, that it had none, and that it was rather a *Nebula* than a *Comet*.

However, ſuſpecting that it might have ſome Motion, I attended the next Night at the ſame Hours, and in the ſame Company; when with ſome Difficulty, by reaſon of the Thickneſs of the Air, we found the two little Stars; but the *Nebula* could not at that Time be ſeen, which we then imputed to the Want of a clearer Sky: But on *Saturday, June* 15, the Moon being abſent, and the Air perfectly clear, we had again a diſtinct View of the two Stars, with an entire Evidence that there remained no Footſtep or Sign of it in the Place where we had firſt ſeen this *Phænomenon*, which we therefore now found to be a Comet, and that being far without the Orb of the Earth, and in itſelf a very ſmall Body, it appeared only like a little Speck of a Cloud, ſuch as would ſcarce have been diſcerned in an ordinary Teleſcope, much leſs by the naked Eye.

XLIV. *Papers omitted.*

1. Extracts from Mr. *Gaſcoigne*'s and Mr. *Crabtrie*'s Letters, proving Mr. *Gaſcoigne* to have been the Inventor of the *Teleſcopick Sights* of Mathematical Inſtruments, and not the *French*, by the Reverend Mr. *W. Derham*, Prebend of *Windſor*, and F. R. S. n. 352. p. 603.

Mr. *De la Hire*, in the firſt Part of his *Tabulæ Aſtron.* publiſhed in 1687. having aſcribed to Mr. *Picard* the *Application of Teleſcopick Sights to Aſtronomical Inſtruments* (which alſo was in effect claimed as his, by Mr. *Auzout* in a Letter in the *Ph. Tranſ.* N. 21. in the Year 1666.) Mr. *Derham* from theſe Letters of Mr. *Gaſcoigne* and Mr. *Crabtrie*, proves that Mr. *Gaſcoigne* as early as the Year 1640. made uſe of theſe *Teleſcopick Sights* in two or more ſorts of his *Micrometers*, and in his *Quadrant* and *Sextant*.

2. Aſtronomiæ *Cometicæ* Synopſis, Autore *Edmundo Halleio* apud *Oxonienſes* Geometriæ Profeſſore *Saviliano*, & R. S. S. n. 292. p. 1882.

XLV. *Account of a Book omitted.*

Aſtronomiæ Phyſicæ & Geometricæ Elementa Auctore *Davide Gregorio*, M. D. Aſtronomiæ Profeſſore *Saviliano*, & R. S. S. *Oxoniæ* 1702. *Folio.* n. 283. p. 1312.

CHAP. IV.

Mechanics. Acouſtics.

To find a Solid of the leaſt Reſiſtance, &c. by Mr. J. Craig. n. 268. p. 747. *Dec.* 21. 1700.

I. 1.] PROBLEMA illud de *inveniendo Solido rotundo, quod minimam in fluido patiatur Reſiſtentiam*, ab incomparabili D. *Iſ. Newtono* jam olim ſolutum, denuo nuper aggreſſi ſunt illuſtriſſimus Marchio *Hoſpitalius*, & celeber. *Jo. Bernoulli* ulterius exponere; quoniam Analyſin ſuam ſupprimere voluit D. *Newtonus*.

Noſtra ejuſdem Problematis Solutio eſt quæ ſequitur.

Lemma.] Invenire Rationem inter Reſiſtentiam, quam patitur Triangulum Rectangulum *AIG*, & reſiſtentiam, quam patitur rectangulum circumſcriptum *AIGg* dum utrumque in fluido movetur juxta Directionem Lineæ *IA*, ab *I* verſus *X*.

Fig. 135.

A puncto quovis *B* ducantur *BC* normalis ad *AG*; & *Bb* parallela ad *AI*, item *BM* normalis ad *AI*. Tum in *bB* capiantur $bH = \frac{CM^2}{BC}$ & $bE = BC$; & per puncta *H*, *E* ducantur rectæ *HA*, *EA*, quæ productæ ſecent *Gg* in *K* & *F*: Dico Reſiſtentiam Trianguli *AIG* eſſe ad Reſiſtentiam Rectanguli *AIGg* ut Area Trianguli *AKG*, ad Aream Trianguli *AFg*. Imò & Reſiſtentiam in partem quamlibet Lineæ *AG* ad Reſiſtentiam in partem correſpondentem Lineæ *Ag*; exem. gra. in *AB* & *Ab* ut Area *AHB* ad Aream *AEB*. Demonſtratio pendet à Theoremate generali, quod facillime deduxi ex Prop. XXXV. Newtoni, p. 324.

Corol. 1.] Sint jam *BG*, *bg* partes infinitæ parvæ Linearum *AG*, *Ag* & producatur *bB* ad *L*; dico Reſiſtentiam in *BG* (quam vocemus *e*) eſſe ad Reſiſtentiam in *bg* (quam vocemus *E*) ut GL^2 ad GB^2.

Nam $e : E :: KHbg : FEbg$, id eſt, $e : E :: bg \times bH : bg \times bE$ (per Lemma præcedens) Ergo $e : E :: bH : bE$, id eſt, $e : E :: \frac{CM^2}{BC} : BC$, (per conſtructionem ſuperioris Lemmatis) Ergo $e : E :: CM^2 : BC^2$. Sed $CM^2 : BC^2 :: GL^2 : GB^2$. (ob ſimilia Triangula *BMC*, *GLB*) Ergo $e : E :: GL^2 : GB^2$. *Q. E. D.*

Corol. 2.] Reſiſtentia in partem infinite parvam *GB* eſt æqualis Cubo Lineæ *GL* diviſo per Quadratum Lineæ *GB*. Nam ſi omnes partes infinite parvæ in Linea *Ag* ut *bg* ſupponantur æquales, tum Reſiſtentia in *bg* per ipſam *bg*, exprimi poſſit, id eſt, $E = bg$, adeoque $E = GL$. Ergo

Ergo per Corollarium primum $e : GL :: GL^3 : GB^2$; unde $e = \frac{GL^3}{GB^2}$.

Q. E. D.

Corol. 3.] Sit r Radius & c Circumferentia cujuſvis Circuli, dico reſiſtentiam in conicam ſuperficiem genitam à rotatione, lineolæ GB circa AI eſſe æqualem producto ex $\frac{C \times BM}{r}$ in $\frac{GL^3}{GB^2}$. Nam Reſiſtentia in Conicam illam ſuperficiem eſt æqualis omnibus reſiſtentiis in lineolam GB, id eſt omnibus e; id eſt æqualis circumferentiæ circuli, cujus radius eſt BM in e multiplicatæ; id eſt, reſiſtentia in Conicam illam ſuperficiem eſt æqualis $\frac{c \times BM}{r} \times e$; adeoque per Corol. 2. æqualis $\frac{c \times BM}{r} \times \frac{GL^3}{GB^2}$. *Q. E. D.*

Problema.] Invenire Lineam curvam, cujus rotatione producatur Solidum rotundum, quod (dum in medio fluido ſecundum axis ſui directionem movetur) minimam patiatur Reſiſtentiam.

Sint OG, GB, duæ particulæ infinitè parvæ in Curvâ quæſitâ, quæ circa AQ rotata producat Solidum rotundum minimæ Reſiſtentiæ. Ducantur BM, GP normales ad AQ, item BL, GN ad AQ, & ON ad BM parallelæ. Jam $\frac{c \times BM \times GL^3}{r \times GB^2}$ eſt Reſiſtentia in ſuperficiem genitam a rotatione lineolæ GB circa AQ, & $\frac{c \times GP \times ON^3}{r \times OG^2}$ eſt Reſiſtentia in ſuperficiem genitam ſimiliter ab OG per *Cor.* 3. Jam utraque hæc Reſiſtentia ſimul ſumpta debet eſſe minima ſcil. $\frac{c \times BM \times GL^3}{r \times GB^2} + \frac{c \times GP \times GN^3}{r \times OG^2}$ = minimæ. Adeoque in linea RS ita ad AQ parallela ut ON ſit $= GL$, quærendum eſt punctum G ut hoc contingat; quod ſupponendo puncta O & B eſſe fixa facile invenietur per notiſſimam Maximorum & Minimorum Methodum. Calculum proſequendo devenietur tandem ad $\frac{BM \times BL}{BG^4} = \frac{GP \times NG}{OG^4}$; unde patet $\frac{BM \times BL}{BG^4} =$ conſtanti; ſic ſi Abſciſſa AM vocetur x, & Ordinata BM, y, erit $BL = dx$, $LG = dy$ (quam conſtantem in toto hoc calculo ſuppoſui) adeoque $BG = dx^2 + dy^2$, unde $\frac{y\,dr}{dx\,dx + dy\,dy^2} =$ conſtanti: Sit a linea quælibet conſtans, & proinde, ut

Fig. 136.

obſervetur Lex homogeneorum erit $\frac{ydx}{dxdx+dydy^2} = \frac{a}{dy^3}$ ut ab Illuſtriſſ. *Hoſpitalio* & celeber. *Jo. Bernoullio* inventum eſt. Et hic obiter clariſſ. *Bernoullio* ſignificare viſum eſt me plurimum delectari methodo ſuâ conſtruendi Curvas ex Æquationibus differentialibus, in quibus deeſt altera ex indeterminatis x vel y, in Actis Lipſicis publicatâ menſe Maio Anni 1700. & per quam eleganter deduxit conſtructionem Curvæ modo quæſitæ, Nov. 1699. pag. 515.

— *on the* ſame *by Mr.* N. Facio. n. 337. p. 172. *May* 17. 1712.

2.] De meâ Solutione (*Londini* impreſsâ) Problematis de *Inveniendo Solido rotundo ſeu Tereti, in quod minima fiat Reſiſtentia*, multa ſcripſit Cl. *Joh. Bernoullius*. Negat ille me, hominem licet ipſi prorſus ignotum, ex tali Solutione, ſecundis Fluxionibus implicata, ad Solutionem illam *Newtonianam* regredi poſſe, cui ſimilem invenit & ipſe *Bernoullius*; talibuſque dictis innuit, Quo tempore iſta ſcriberet *Bernoullius*, Regreſſum hujuſmodi utique facilem ipſi fuiſſe. Sed obſtant pluſculum *Jac. Bernoullii* Viri Cl. Literæ, quibus patet nec ipſum, quo tempore ſcriberet, nec ejus Fratrem Transformationem illam noſtram Æquationum Fluxionibus involutarum cognoviſſe; qua multiplicantur in Productum, verbi gratia, $x^{\varkappa}\, y^{\lambda}$ rite determinandum, vel etiam in Quantitatem aliam complexam. Sub Multiplicatione autem continetur & Diviſio. Hanc autem Transformationem, a me Anno 1687 & 1688 inventam, *Hugenium* & *Moyvræum* edocui à quibus ejuſdem Scientia ad alios forſan defluxerit. Tentamine autem olim facto, comperi *Newtonum* Præſidem noſtrum digniſſimum illam vel eo jam tempore non ignoraſſe; aut potius omnium primum inveniſſe.

Sed reſpondere cum potuiſſem pluribus modis ad Cl. *Joh. Bernoullii* velitationes, volui Inveſtigationem illam omnium longe ſimpliciſſimam Actis Lipſienſibus inſerere, quam *Joh. Bernoullius* non poſſet reſpuere; & ex qua præterea intelligeret, ipſum immerito falſi arguiſſe quæ ſcripſeram de *Invenienda* pariter *Linea Breviſſimi Deſcenſus*, adhibita ritè conſideratione motus quaſi Radii Lucis continuè refracti, juxta *Fermatii* Doctrinam Refractionum.

Illud jam debere videor, ut ex Æquatione illa, quam in Pagina 16. exhibui, rite deductam Æquationem primis tantum Fluxionibus involutam ſcriptis conſignem: Quam ſcilicet requirebat *Johannes Bernoullius*, & me prorſus negabat invenire poſſe. Nec enim iſta ſcriptis mandari poterunt, quin Via ſternatur ad augendam inter Mathematicos Geometriæ ſecretioris Scientiam.

Videantur in Tractatulo noſtro quæ ad Figuram ejuſdem II. pertinent.

Fig. 137, 138. In adjuncta *Figura* ſit G centrum Circuli Oſculantis AEF, qui cum Sectione Solidi quæſiti, cujus axis ſit SY, quam intime coincidat in

in *A*. Eritque hujus Circuli Radius *C A* vel $u = \frac{3psx}{tt} - \frac{px}{s}$ quæ erat Solutio noſtra.

Fiat, ut prius, *AS* ad Solidi Axem *YS* perpendicularis $= x$; cujus fiat Fluxio invariatæ Magnitudinis $AB = \dot{x}$: Sitque *BE* ad Axem parallela $= \dot{y}$; rurſuſque erigatur $EG = \dot{x}$; et erit *GF* ad Axem parallela $= \dot{y} + \dot{\dot{y}}$.

Erit autem p ad t ut u ſeu $\frac{3psx}{tt} - \frac{px}{s}$ ad $\frac{3sx}{t} - \frac{tx}{s}$ ſive $\frac{3\dot{y}x}{\dot{x}} - \frac{\dot{x}x}{\dot{y}}$; quod æquabitur ipſi n ſeu *AD* ad Axem parallelæ, poſita ſcilicet *CD* ad eundem Axem perpendiculari: quæ *CD* vocetur m.

Rurſus erit p ad s ut u ſeu $\frac{3psx}{tt} - \frac{px}{s}$ ad $\frac{3ssx}{tt} - x$, ſive $\frac{3\dot{y}\dot{\dot{y}}x}{\dot{x}\dot{x}} - x$; quod æquabitur ipſi m ſeu *CD*. Cujus Valorem dediſſe otioſum quidem hic eſt, ſed uſum habebit in ſequentibus.

Jam vero ex Oſculantis Circuli *AEF* Proprietate habebitur, productis ipſis *BA*, *BE* ad alteram uſque Circumferentiæ partem, $\dot{x} \times \overline{2m + \dot{x}} = \dot{y} \times \overline{2n - \dot{y}}$.

Rurſuſque ex ejuſdem Circuli Proprietate habebitur, productis ipſis *GE*, *GF* ad alteram uſque Circumferentiæ partem, $\dot{x} \times \overline{2m + 3\dot{x}} = \dot{y} + \dot{\dot{y}} \times \overline{2n - 3\dot{y} - y}$.

Ergo, ſubducta priori hac Æquatione a poſteriori, erit $2\dot{x}\dot{x} = -2yy - yy + 2ny - 3yy - yy$.

Deletiſque Terminis infinite minoribus quam ſint reliqui, erit $2\dot{x}\dot{x} = -2yy + 2ny$.

Subſtitutoque ipſius n Valore, erit $\dot{x}\dot{x} = -\dot{y}\dot{y} + \frac{3x\dot{y}\dot{y}}{\dot{x}} - \frac{x\dot{x}\dot{y}}{\dot{y}}$:

Id eſt $\dot{x}^3\dot{y} + \dot{x}\dot{y}^3 - 3x\dot{y}\dot{y}\dot{y} + x\dot{x}\dot{x}\dot{y} = 0$.

Com-

1 Componitur hæc Æquatio ex ſolis Indeterminatis x, $\dot{y}$, earumque Fluxionibus $\dot{x}$, $\dot{y}$, invariabilique Quantitate $\dot{x}$, Quantitatibuſve Coefficientibus datis. Bina autem ſunt Paria Terminorum in quibus occurrunt eædem utrinque literæ, literarumque Poteſtates, niſi quatenus Quantitas Fluens per Literam unam expreſſa in Fluxionem convertitur, vel Fluxio in Fluentem. Quæ Paria Terminorum ſunt $\dot{x}^3\,\dot{y} + x\,\dot{x}\,\dot{x}\,\dot{y}$, & $\dot{x}\,\dot{y}^3 - 3x\,\dot{y}\,\dot{y}\,\dot{y}$; ex Terminis utique Generatoribus duobus duntaxat orta. In tota enim Æquatione nihil obſtat, quominus ipſa transformetur, ſcilicet Multiplicatione facta in $x^{\kappa}\,\dot{y}^{\lambda}$, determinatis rite ipſis Indicibus κ & λ, ut ea ratione nova Æquatio proveniens tractabilis evadat.

Ergo juxta noſtram iſtarum Transformationum Theoriam, in Generatore ex quo exoritur Terminorum par primum unico Aſteriſco notatum, erit Numerus Dimenſionum Indeterminatæ x ad Numerum Dimenſionum Indeterminatæ $\dot{y}$, id eſt, Erit $1 + \kappa$ ad $1 + \lambda$, u Coefficiens 1 in Termino $\dot{x}^3\,\dot{y}$ ad Coefficientem 1 in Termino $x\,\dot{x}\,\dot{x}\,\dot{y}$. Rurſus in Generatore, ex quo exoritur Terminorum par alterum Aſteriſco duplici notatum, Erit Numerus Dimenſionum Indeterminatæ x ad Numerum Dimenſionum Indeterminatæ $\dot{y}$, id eſt, Erit $1 + \kappa$ ad $1 + \lambda$, ut Coefficiens 1 in Termino $\dot{x}\,\dot{y}^3$ ad Coefficientem -3 in Termino $-3x\,\dot{y}\,\dot{y}\,\dot{y}$; unde fit $\kappa = -\frac{1}{2}$, & $\lambda = -\frac{1}{2}$; ac proinde Multiplicator $x^{\kappa}\,\dot{y}^{\lambda} = x^{-\frac{1}{2}} \times \dot{y}^{-\frac{1}{2}}$.

Erit igitur $-x^{-\frac{1}{2}}\,x^2\,\dot{y}^{-\frac{1}{2}} - x^{-\frac{1}{2}}\,\dot{y}^{\frac{3}{2}} = \pm q$ Æquatio ſuperioris Æquationis per $x^{-\frac{3}{2}}\,\dot{y}^{-\frac{1}{2}}$ multiplicatæ Generatrix: Eſt autem q Quantitas determinata. Quam Æquationem Generatricem, (Fluentem autem vocant alii) ſi quadraveris, ut tollantur Radices, proveniet $x^{-1}\,\dot{x}^4\,\dot{y}^{-1} + 2x^{-1}\,\dot{x}^2\,\dot{y} + x^{-1}\,\dot{y}^3 = qq$; id eſt $\frac{\dot{x}^4 + 2\dot{x}^2\,\dot{y}^2 + \dot{y}^4}{x\,\dot{y}} = qq$. Quæ ipſa eſt Æquatio *Newtoniana*, quam

& *Joh. Bernoullius* invenit, & ipſe ego antehac erui, facillima omnium quæ ſperari poſſint ejuſdem Æquationis Inveſtigatione. Determinatur autem Quantitas qq, vel datis Poſitione Axe indefinito ΥS, Puncto A, & Solidi Tangente in A; vel datis Poſitione Puncto A, Centro Oſculantis Circuli C, & AD ad Axem Solidi parallela.

II.

II. *Problema.*] Invenire Lineam Celerrimi Deſcenſus.

To find a Live *of the* Quickeſt *Deſcent, by Mr.* J. Craig. n. 268. p. 750. *Dec.* 21. 1700.

Sint BC, CD duæ particulæ infinitè parvæ in curva quæſita. Jam Curva iila debet eſſe talis, ut tranſitus a B ad D poſt caſum a horizontali $A\mathcal{Q}$ fiat in tempore minimo: quærendum itaque eſt punctum in Linea RS (ita ad $A\mathcal{Q}$ parallela ut differentiæ Ordinatarum GC, DE ſint æquales) tale punctum C ut hoc contingat. Fig. 139.

Jam velocitas ejus in puncto C eſt $\sqrt{LC}$ & velocitas in puncto D eſt $\sqrt{\mathcal{Q}D}$; Ergo $\frac{BC}{\sqrt{LC}}$ eſt tempus Deſcenſus per BC, & etiam $\frac{CD}{\sqrt{\mathcal{Q}D}}$ eſt tempus Deſcenſus per CD (per Prop. liv. pag. 158. Newtoni) Ergo punctum C debet eſſe tale ut $\frac{BC}{\sqrt{LG}} + \frac{CD}{\sqrt{\mathcal{Q}D}} =$ Minimo. Supponendo B & D eſſe fixa, ſint conſtantes $GC = DE = m$, $LC = b$, $\mathcal{Q}D = p$; indeterminatæ $BG = u$, $CE = z$; unde $\frac{\sqrt{m^2+u^2}}{\sqrt{b}} + \frac{\sqrt{m^2+x^2}}{\sqrt{p}} =$ Minimo; Ergo

$$\frac{u\,du}{b^{\frac{1}{2}}\sqrt{m^2+u^2}} + \frac{z\,dz}{1p\sqrt{m^2+z^2}} = o \text{ ſed } du = -dz \text{ (quia } v+z = \text{conſtanti)}$$

Ergo $\frac{u}{b\,1\sqrt{m^2+u^2}} = \frac{z}{p\frac{1}{2}\sqrt{m^2+z^2}}$; unde patet $\frac{u}{b\frac{1}{2}\sqrt{m^2+u^2}} =$ conſtanti; ſit jam Abſciſſa $AL = x$; Ordinata $LG = y$; adeoque $BG = dx$, $GC = dy$, $BC = \sqrt{dx^2}$; ſitque a linea quælibet conſtans, Erit $\frac{dx}{y\frac{1}{2}\sqrt{dx^2+dy^2}} = \frac{1}{\sqrt{a}}$,

unde $dx\sqrt{a} = \sqrt{y}\,x\sqrt{dx^2+dy^2}$. Sed in omni Curva dx eſt, ad $\sqrt{dx^2+dy^2}$ ut Subtangens ad Tangentem; Ergo talis eſt natura Curvæ quæſitæ, ut ejus Subtangens ſit ad Tangentem ut $\sqrt{a}$ ad $\sqrt{y}$. Quam utique Cycloidis proprietatem eſſe ſciunt omnes, quibus notum eſt Tangentem Cycloidis eſſe parallelam Chordæ arcus Contermini in Circulo genitore, cujus Diameter eſt a, & cujus Vertex deorſum ſpectat.

Et pari facilitate Curvam invenire poſſum Celerrimi Deſcenſus pro qualibet alia gravitatis Hypotheſi.

III. *Inventio Curvæ, quam Corpus deſcendens breviſſimo tempore deſcriberet; urgente Vi centripetâ ad datum punctum tendente, quæ creſcat vel decreſcat juxta quamvis Potentiam diſtantiæ à Centro; dato nempe imo Curvæ puncto & altitudine in principio Caſus.*

To find the Curve, *which a* Falling Body *would* deſcribe, &c. *by Mr.* J. Machin. n. 358. p. 860.

Sit

Sit centrum Virium C, (*Fig.* 140, 141,) quo centro ad diſtantiam CB æqualem altitudini unde Corpus caſurum eſt, deſcribatur Circulus BEG, & fiat angulus BCG rectus. Ponatur A punctum Curvæ infimum, ubi axi CB occurrit ad datam diſtantiam CA. Oportet invenire punctum Q, ubi Curva celerrimi deſcenſûs EQA occurrit circulo QF, ad datam aliam diſtantiam CF. Problema hoc duos habet caſus, quorum alter pendet ab Hyperbola & Circulo, alter ab Ellipſi & Circulo.

Caſ. 1. Si fuerit Vis centripeta reciproce ut diſtantia à Centro.
Fig. 140. Sit KLM Hyperbola quævis rectangula Centro C & Aſymptoto CB deſcripta, quæ occurrat normalibus BK, AM ſuper ipſam BC ad puncta B, A erectis, in K & M; Ordinatæ vero cuilibet intermediæ FL ad punctum F erectæ in L. Fiat CD ad CG ut $\surd AFLM$ ad $\surd ABKM$, & ſit DH normalis ſuper CG: dein capiatur Sector RCB ad Aream $HDCB$, ut data Area Hyperbolica $ABKM$ ad datum Rectangulum $CA \times AM$. Tum recta RC occurret Circulo FQ in puncto Q, quod quidem eſt ad Curvam celerrimi deſcenſus EQA.

Habebitur autem punctum E, à quo inciperet corporis caſus, capiendo Sectorem BCE ad Aream Quadrantis BCG, in eadem ratione Areæ Hyperbolicæ $ABKM$ ad rectangulum ſub CA & AM contentum.

Coroll. Hinc ſi recta RC, circa centrum C revoluta, faciat Sectores RCB proportionales Areis $HDCB$, in quibus quadrata Baſium CD ſumuntur in progreſſione Arithmeticâ: tum rectæ CR interſecabunt Curvam EQA ad diſtantias à centro CQ, quæ decreſcant in Progreſſione Geometricâ.

Caſ. 2. Si vero Vis centripeta fuerit reciproce ut alia quævis Poteſtas diſtantiæ à centro; ſit $n+1$ Index iſtius Poteſtatis (ubi n poteſt eſſe Numerus quilibet integer vel fractus, affirmativus vel negativus) ſitque $H = CB$ altitudo maxima Curvæ quæſitæ EQA, $b = CA$ altitudo minima ejuſdem, & $A = CF$ altitudo alia quævis intermedia.

In recta CG capiatur CD ad CB ut $\surd b^n$ ad $\surd H^n$, atque etiam
Fig. 141. CH ad CD ut $\surd \overline{A^n - b^n}$ ad $\surd \overline{H^n - b^n}$. Centro C, ſemiaxibus CD, CB, deſcribatur Ellipſis BLD, cui occurrat ordinatim applicata HL in puncto L; & ducatur recta LK, quæ Ellipſin tangat in L, & Axi minori CD producto conveniat in K: dein Tangenti KL parallela ducatur NM, circulum $BEMG$ tangens in M, & ipſi CD occurrens in N. Denique capiatur Sector RCB, qui ſit ad Aream NMB, LKN, inter Circulum & Ellipſin & utriuſque Tangentes rectamque NK comprehenſam, in ratione Numeri binarii ad Numerum n. Tum recta RC interſecabit Circulum FQ in puncto Q, quod erit ad Curvam celerrimi Deſcenſus EQA.

Quod

Quod ſi fiat Sector *B C E* ad aream *B D G*, inter Ellipſeos & Circuli Quadrantes interceptam, in ratione dictâ Binarii ad Numerum *n*, coeuntibus ſcilicet punctis *L*, *D* & *M*, *G*; (ob $A^n = H^n$) erit punctum *E*, unde inchoaretur Caſus Corporis breviſſimo tempore deſcendentis ad *A*, deſcenſuque ſuo Curvam *E Q A* deſcribentis, quam tangit recta *C E* in *E*, quamque ad angulos rectos ſecat *C B* in *A*.

Harum Conſtructionum Demonſtrationes è Celeberrimi D. *Newtoni Quadraturis*, ejuſdemque *Philoſ. Nat. Principiis* (Prop. XXXIX. & ſequentibus aliquibus) petitæ, aliâ datâ occaſione oſtendentur. Problema autem eſt alterius generis, Deſcribere Curvas, per quas Corpora, de puncto ſummo *E*, ſeu principio caſus, demiſſa, celerrimo deſcenſu ad inferiora data puncta *Q*, urgente qualibet Vi centripeta, ferrentur; cujus quidem ſolutio in poteſtate eſt. In præſentia ſufficiat generalem hujuſmodi Curvarum tradidiſſe Ideam, earumque ad Circuli & Hyperbolæ Quadraturas relationes indicâſſe, abſque quibus eaſdem Geometrice conſtruere haud adeo proclive eſt.

The Laws *of* Attraction, *&c. by Dr.* John Keill, n. 315. p. 97.

IV. Ponenda ſunt fundamenti loco hæc tria, quibus omnis Phyſicæ innititur, principia. 1. Spatium inane. 2. Quantitatis in infinitum diviſibilitas. 3. Materiæ vis Attractrix. Dari ſpatium inane conſtat ex motu corporum. Quantitatis in infinitum diviſibilitatem ex continuæ quantitatis naturâ demonſtrant Geometræ. Materiæ ineſſe vim attractricem confirmat experientia. Ex duobus primis principiis ſequitur.

Theor. 1.] *Materiæ exigua quælibet particula poteſt ita ſpatium quantumvis magnum occupare, ut pororum ſeu omnium meatuum diametri ſint datâ rectâ minores, vel ut particulæ omnes ſint à ſe invicem remotæ intervallo datâ rectâ minore.*

Theor. 2.] *Dari poſſunt duo corpora mole æqualia, at pondere ſeu denſitate (id eſt quantitate materiæ) utcunque inæqualia, in quibus erunt meatuum ſeu pororum ſummæ fere æquales.*

Sit V. G. digitus cubicus alter auri, alter aeris: quamvis materia in cubo aureo viceſies millies ſuperat materiam in cubo aerio, fieri tamen poteſt ut ſpatia vacua in digito cubico auri ſint fere æqualia ſpatiis vacuis in digito cubico aeris, ſcil. ut auri vacuitates ſint ad vacuitates aeris ut 999999 ad 1000000.

Theor. 3.] *Particulæ quæ aquam vel aerem vel alia ejuſmodi fluida conſtituunt (ſi modo ſe tangant) non ſunt abſolute ſolidæ, ſed ex aliis compoſitæ particulis multos meatus & poros intra ſe continentibus.*

Particulæ corporum minimæ & abſolute ſolidæ, hoc eſt vacui omnino expertes, vocentur primæ compoſitionis; Moleculæ ex pluribus hiſce particulis coaleſcentibus ortæ vocentur particulæ ſecundæ compoſitionis; Moles ex pluribus moleculis coeuntibus conflatæ, vocentur particulæ tertiæ compoſitionis; & ſic deinceps, donec tandem perventum fuerit ad particulas, è quibus corporum fit ultima compoſitio, & in quas eorundem fit prima reſolutio.

Materiæ ineſſe vim Attractricem, quâ omnis materiæ particula trahit ad ſe omnem aliam materiæ particulam, & viciſſim trahitur, primus ex Phænomenis collegit D. *Iſ. Newtonus*. Vis hæc datâ materiâ in diverſis diſtantiis reciprocè proportionalis eſt quadratis diſtantiarum ; ex quâ oritur vis illa quam Gravitatem dicimus, quâ corpora omnia terreſtria ad terram recta feruntur, eſtque pondus corporum quantitati materiæ ſemper proportionale. Prolatâ hâc, quam ipſe primus detexit, Materiæ vi Attractrice, omnes Planetarum motus Cometarumque Phaſes pulcherrimè explicavit.

Divina ſagaciſſimi viri inventa ſæpenumero mecum recolens, in eam tandem cogitationem incidi, principium quoddam *Newtoniano* non abſimile, ad Phænomena terreſtria explicanda, adhiberi poſſe. Poſt iterata ſæpius experimenta, materiæ terreſtri ineſſe deprehendi vim quandam attractricem, ex qua plurimorum Phænomenωn ratio petenda eſt ; Meaque hâc de re cogitata, abhinc quinquennio, D. *Newtono* indicavi ; ex eo autem intellexi, eadem fere, quæ ipſe inveſtigaveram, ſibi diu ante animadverſa fuiſſe. Quæſtiones aliquot ad hanc vim attractricem ſpectantes, ſub finem Optices abhinc biennio Latine editæ, propoſuit D. *Nowtonus* ; quem cum iſtiuſmodi ſtudia ulterius excolere ætas ingraveſcens, & alia negotia vetant, tanti viri veſtigiis inſiſtere, eumque longo licet intervallo ſequi, haud alienum duxi. Impræſentiarum nuda quædam proponam Theoremata, quæ fortaſſe aliquando fuſius enunciata & demonſtrata, juſto volumine ſum traditurus.

Theor. 4.] *Præter vim illam Attractricem, quâ Planetarum Cometarumque corpora, in propriis orbitis retinentur, alia etiam ineſt materiæ potentia, quâ ſingulæ, ex quibus illa conſtat, particulæ ſe invicem attrahunt, & reciprocè à ſe invicem attrahuntur : quæ vis decreſcit in majore quam duplicatâ ratione diſtantiæ augeſcentis.*

Theorema hoc multis poteſt probari experimentis ; at ratio quâ minuitur vis illa, dum à ſe invicem recedunt particulæ, num ſcilicet ſit triplicata, quadruplicata, vel alia quævis diſtantiarum augeſcentium ratio, quæ major ſit duplicatâ, nondum æquè per experimenta patet ; erit fortaſſe aliquando tempus, cum accuratiore adhibitâ diligentiâ innoteſcet.

Theor. 5.] *Si corpus conſtet ex particulis, quarum ſingulæ vi pollent attractrice, in triplicatâ vel pluſquam triplicatâ ratione diſtantiarum decreſcente ; erit vis qua ab eo corpore urgentur corpuſculum, in ipſo contactu, vel intervalla à contactu infinite exiguo, infinite major, quam ſi corpuſculum illud ad datam à dicto corpore diſtantiam locaretur.*

Vide Prop. 80. & 91. Princip. *Newtoni.*

Theor. 6.] *Iiſdem poſitis, ſi vis illa attractiva in aſſignabili diſtantia, ad Gravitatem obtineat rationem finitam ; eadem in ipſo contactu, vel in diſtantiâ infinite parvâ, vi Gravitatis erit infinite major.*

Theor.

Theor. 7.] *Si verò in ipſo contactu, vis corporum attractiva ad Gravitatem obtineat rationem finitam, eadem in omni diſtantiâ aſſignabili eſt vi gravitatis infinite minor, adeoque evaneſcit.*

Theor. 8.] *Vis attractiva, qua pollent ſingulæ materiæ particulæ in ipſo contactu, vim gravitatis prope in immenſum ſuperat; non tamen eſt vi Gravitatis infinite major; adeoque, in data diſtantia, vis illa evaneſcet.*

Vis igitur hæc materiæ ſuperaddita, non niſi per ſpatiola admodum perexigua diffunditur; in majoribus diſtantiis prorſus nulla eſt; unde motus corporum Cœleſtium (quæ longis intervallis à ſe invicem diſjuncta ſunt) per vim hanc attractivam nullâ ratione turbari poſſunt, ſed eâdem ratione continuò peraguntur, ac ſi vis illa à corporibus iis prorſus abeſſet.

Theor. 9.] *Si corpuſculum aliquod corpus tangat, vis quâ urgetur illud corpuſculum, hoc eſt, vis qua cum eo corpore cohæret, erit quantitati contactus proportionalis; nam partes à contactu remotiores nihil conferunt ad cohærentiam.*

Adeoque pro vario particularum contactu varii orientur cohærentiæ gradus; omnium autem maximæ ſunt vires cohærentiæ, quando ſuperficies, in quibus ſe invicem tangunt corpora, planæ exiſtunt; quo in caſu, cæteris paribus, vis quâ corpuſculum cum aliis cohæret, erit ut ſuperficierum partes ſeſe tangentes.

Hinc patet ratio, cur duo marmora exactiſſimè polita, & ſeſe ſecundum ſuperficies planas tangentia, à ſe invicem divelli non poſſunt, niſi à pondere, quod Gravitatem Aeris incumbentis multum ſuperat.

Hinc etiam decantatiſſimi iſtius Problematis, de cohærentia materiæ, ſolutio elici poteſt.

Theor. 10.] *Ea corpuſcula facillimè à ſe invicem ſeparantur, quarum contactus cum aliis ſunt pauciſſimi, & minimi; quales contingere ſolent in corpuſculis Sphæricis infinite exiguis.*

Hinc fluiditatis ratio redditur.

Theor. 11.] *Vis quâ corpuſculum aliquod ad aliud corpus maxime propinquum attrahitur, quantitatem ſuam non mutat, ſive augeatur corporis attrahentis materia, ſive minuatur, eâdem manente corporis denſitate, & corpuſculi diſtantiâ.*

Nam cum vires particularum Attractrices per minima tantum diffundantur ſpatia; liquet partes remotiores ad *C D* & *E*, nihil conferre ad attrahendum corpuſculum *A*. Adeoque eâdem vi verſus *B* trahetur corpuſculum, ſive adſint hæ partes, ſive amoveantur, ſive denique aliæ ipſis conjungantur. Fig. 142.

Theor. 12.] *Si ea ſit corporis alicujus textura, ut particulæ ultimæ compoſitionis, per vim quandam externam (qualis eſt pondus eas comprimens, vel ab altero corpore proveniens ictus) à primigeniis ſuis contactibus paululum dimoveantur, nec interim in novos contactus commigrent, particulæ, per vim attractivam ſeſe mutuo petentes, ad contactus primigenios citò redibunt: iiſdem vero redeuntibus particularum corpus quodvis componentium contactibus & poſi-*

tionibus, eadem quoque redibit corporis figura; adeoque per vim attractivam corpora priſtinas quas amiſerunt figuras poſſunt denuo recuperare.

Hinc Elaſticitatis ratio reddi poteſt. Cum autem per vim Elaſticam corpora, in ſe invicem impingentia, à ſe mutuo reſiliant (uti demonſtratum eſt in Lectionibus noſtris Phyſicis) à vi attractivâ corporum oriri etiam debet eorundem à ſe invicem diſceſſus.

Theor. 13.] *Quod ſi ea ſit corporis textura, ut particulæ à prioribus contactibus per vim impreſſam dimotæ, in alios qui ejuſdem ſunt gradûs immediate deveniant, corpus illud in priſtinam figuram non ſe reſtituet.*

Hinc qualis ſit textura, in qua corporum mollities conſiſtit, intelligi poteſt.

Theor. 14.] *Particulæ materiæ pro diverſa ipſarum ſtructurâ & compoſitione diverſis pollebunt viribus attractivis; puta non erit æquè fortis attractio, cum particula datæ magnitudinis pluribus perforata ſit meatibus, ac ſi omnino ſolida & vacui expers eſſet.*

Theor. 15.] *Particularum perfectè ſolidarum vires attractivæ ex figuris ipſarum multum pendent:* Nam ſi parva aliqua materiæ particula in laminam circularem indefinite exiguæ craſſitudinis formetur, & corpuſculum in rectâ per Centrum tranſeunte, & ad planum circuli Normalis locetur; ſitque diſtantia corpuſculi æqualis decimæ parti ſemidiametri circuli: vis, qua urgetur corpuſculum, triceſies minor erit, quam ſi materia attrahens coaleſceret in Sphæram, & virtus totius particulæ ex uno quaſi puncto Phyſico diffunderetur. Quin etiam eadem circularis lamella fortius ad ſe trahit corpuſculum, quam alia ejuſdem ponderis particula, quæ in tenuem & longum formatur Cylindrum.

Theor. 16.] *Sales ſunt corpora, quorum particulæ ultimæ compoſitionis magnâ vi attractivâ pollent, inter quas tamen particulas plurimi interjacent meatus, particulis, quas habet aqua, ultimæ compoſitionis pervii: quæ igitur a ſalinis particulas fortiter attractæ, in eas cum impetu ruunt, & à mutuo contactu eas disjungunt, cohærentiamque ſalium diſſolvunt.*

Theor. 17.] *Si corpuſcula duo viribus attractivis decreſcentibus in triplicatâ aut pluſquam triplicatâ ratione diſtantiarum ſe mutuo petunt; erit velocitas in ſe invicem impingentium infinite major quam in dato intervallo.* Vide Prop. 39. Princip. Newtoni.

Theor. 18.] *Corporis aquâ gravioris eo uſque diminui poteſt magnitudo, ut tandem in aquâ ſuſpenſum maneat, nec vi propriæ gravitatis deſcendat.*

Hinc patet ratio, cur particulæ Salinæ, Metallicæ, & aliæ ejuſmodi, in minima redactæ, in ſuis menſtruis ſuſpenſæ hæreant.

Theor. 19.] *Corpora majora minore velocitate ad ſe invicem accedunt, quam minora.*

Fig. 143, 144. Vis enim, quâ ſe mutuo petunt corpora *A* & *B*, particulis maxime propinquis tantum ineſt; remotiorum quippe vires nullæ ſunt. Non igitur major vis adhibetur ad movenda corpora *A* & *B* quam ad particulas *c* & *d* movendas, ſed corporum eadem vi motorum velocitates ſunt corporibus reciproce proportionales: unde erit velocitas quâ corpus *A* tendit verſus *B*, ad velocitatem, quâ particula *c*, à corpore

ſoluta, verſus idem *B* tenderet, ut particula *c* ad corpus *A*. Multo igitur minor eſt velocitas corporis *A*, quam foret velocitas particulæ *c* a corpore ſolutæ.

Hinc fit, ut corporum majorum motus ſuâ naturâ adeo languidus & lentus ſit, ut ab ambiente fluido & aliis circumjacentibus corporibus plerumque impediatur. In minimis verò corpuſculis viget virtus, & ab iis perplurimi producuntur effectus: tanto plus Energiæ minoribus ineſt corporibus, quam majoribus.

Hinc patet ratio iſtius Axiomatis Chymici, Sales non agunt niſi ſoluti.

Theor. 20.] *Duo Corpuſcula ſeſe non contingentia, adeo ſibi vicina locari poſſunt, ut vis, quâ ſe mutuo petunt, vim gravitatis multum ſuperet.*

Theor. 21.] *Si corpuſculum in fluido locatum à particulis ambientibus undique æqualiter trahatur, nullus exinde orietur corpuſculi motus; quod ſi ab aliis particulis magis, ab aliis minus urgeatur, ad eam partem tendet corpuſculum, ubi major eſt attractio: & motus productus inæqualitati attractionis reſpondebit, ſcilicet in majori inæqualite major erit motus, in minore minor.*

Theor. 22.] *Corpuſcula in fluido natantia & magis ſe invicem trahentia quam fluidi particulas interjectas, depulſis fluidi particulis ad ſe invicem accedent ea vi, qua ipſorum attractio mutua ſuperat attractionem particularum fluidi.*

Theor. 23.] *Si corpus aliquod in fluido locetur, cujus partes fluidi particulas magis ad ſe trahunt, quam fluidi particulæ à ſe invicem trahuntur; ſintque in corpore meatus plurimi particulis fluidi pervii, per hos meatus fluidum illud cito ſe diffundet; & ſi partium in corpore connexio non tam firma ſit, quin ab impetu irruentium particularum ſuperari poſſit, orietur exinde corporis immerſi diſſolutio.*

Hinc ut menſtruum dato corpori diſſolvendo ſit idoneum, tria requiruntur. 1. Ut partes corporis particulas menſtrui magis ad ſe trahant, quam eæ à ſe invicem trahuntur. 2. Ut corpus habeat meatus particulis menſtrui patentes, & pervios. 3. Ut cohærentia particularum corpus conſtituentium tanta non ſit, quin ab impetu irruentium particularum menſtrui divelli poſſit. Hinc quoque conſtat particulas Spiritum Vini conſtituentes, magis à ſe invicem trahi, quam à particulis corporis ſalini in Spiritu Vini demerſi.

Theor. 24.] *Si corpuſcula in fluido natantia, & ſe invicem petentia, elaſtica ſint, poſt congreſſum, à ſe mutuo reſilient; & inde alia corpuſcula rurſus impingentia, denuo reflectentur: ex quo fient innumeri alii cum aliis corpuſculis conflictus continuæque reſilitiones. Per vim autem attractivam, continuo augebitur corpuſculorum velocitas, & ſenſui patebit partium motus Inteſtinus; ſed prout fortius aut imbecillius ſe invicem trahunt corpuſcula, & pro variâ, qua pollent Elaſticitate, varii erunt hi motus, & diverſis gradibus atque temporibus fient ſenſibiles.*

Theor. 25.] *Si corpuſcula ſe invicem trahentia, ſe mutuò contingant nullus orietur motus; propius enim accedere nequeunt. Si ad exiguum admodum à ſe invicem ſeponantur ſpatium, orietur motus; ſed ſi longius diſtent, non*

majore

majore vi ſe invicem trahent, quam fluidi particulas interjectas; adeoque nullus producetur motus.

Ex hiſce principiis pendent omnia Fermentationis & Efferveſcentiæ Phænomena. Hinc patet ratio, cur oleum Vitrioli, cui paululum aquæ immittitur, efferveſcit atque ebullit: corpuſcula enim ſalina infusâ aquâ à mutuo contactu paululum dimoventur; unde cum magis ſe invicem trahant quàm aquæ Particulas, & cùm undique æqualiter non trahuntur, motum exinde oriri neceſſe eſt.

Hinc etiam liquet ratio, cur tanta cietur ebullitio, cum limatura Chalybis mixturæ ſupradictæ injicitur: particulæ enim Chalybis magnâ pollent Elaſticitate, unde valida oritur reflectio. Hinc etiam videre eſt, cur menſtrua quædam fortiori vi agunt, citiuſque corpus aliquod diſſolvunt, ſi aquâ dilutiora fiant.

Theor. 26.] *Si corpuſcula ſe mutuo attrahentia vi Elaſticâ careant, à ſe invicem non reflectuntur; ſed congeries ſeu moleculas particularum efficient, unde fiet* Coagulum: *& ſi particularum ſic coacervatarum Gravitas ſuperet Gravitatem fluidi, ſuccedet quoque* Præcipitatio. *Oriri quoque poteſt præcipitatio ex auctâ vel diminutâ Gravitate menſtrui, in quo natant corpuſcula.*

Theor. 27.] *Si corpuſculorum ſeſe invicem attrahentium, & in fluido natantium, ea ſit figura, ut in datis quibuſdam ipſorum partibus, majori vi attractivâ polleant, quam in aliis, & major ſit in iiſdem contactus; corpuſcula illa coibunt in corpora datas figuras habentia, & inde emergent Cryſtalliſationes; corpuſculorumque componentium figuræ ex datâ figurâ Cryſtalli per Geometriam determinari poſſunt.*

Theor. 28.] *Si corpuſcula magis trahantur à fluidi particulis, quam à ſe invicem; fiet ut quaſi ſe mutuo fugientes, à ſe invicem recedant, & per omne fluidum citò diffundentur.*

Theor. 29.] *Si inter duas fluidi particulas aliquod intercedat corpuſculum, cujus binæ oppoſitæ facies maximis pollent viribus attractivis, hoc interjectum corpuſculum particulas fluidi ſibi agglutinabit; & plura iſtiuſmodi corpuſcula per fluidum diffuſa ejus particulas omnes in corpus firmum compingent, fluidumque in* Glaciem *reducent.*

Theor. 30.] *Si corpus aliquod maximam emittat effluviorum copiam, quorum vires attractrices ſunt fortiſſimæ; cum effluvia hæc corpori alicui leviuſculo appropinquent, ipſorum vires attractrices Gravitatem corporis levioris tandem ſuperabunt; & effluvia corpus illud ad ſe ſurſum trahent; cumque multo magis conferta ſunt Effluvia, in minoribus ab emittente corpore diſtantiis, quam in majoribus; corpus leve verſus denſiora Effluvia ſemper urgebitur, donec tandem ipſi corpori effluvia emittenti adhæreat. Hinc plurima* Electricitatis *Phænomena explicari poſſunt.*

Contra noſtram hanc de viribus attractricibus doctrinam, fortaſſe objiciet aliquis; Si vis hæc attractrix omni ineſſet materiæ; corpora ponderoſiora & plus materiæ in dato ſpatio habentia, plus debere attrahere, quàm corpora minùs gravia, quod experientiæ repugnat. Sed huic objectioni facile reſpondetur. Particulæ ſcilicet ultimæ compoſi-

tionis (quibus ſolis tribuitur vis attractrix) confertim juxta ſe invicem locatæ, poſſunt corpus ponderoſum conſtituere, etiamſi ipſæ in ſe ſint rariores, quam eæ quæ corpus leve conſtituunt ultimæ compoſitionis particulæ, à ſe invicem remotiores, & plures & patentiores meatus inter ſe habentes.

Alia multa ſunt Naturæ Phænomena, quæ mihi videntur iiſdem principiis explicari poſſe, uti aſcenſus ſucci in Plantis & Arboribus, foliorum & florum determinatæ & conſtantes figuræ, eorumque virtutes ſpecificæ, &c. Multa quoque quæ in corpore animali quotidie occurrunt; præcipue quæ ad fluidorum curſus Secretioneſque ſpectant, ab iiſdem materiæ qualitatibus pendent, & hinc morborum *Theoriæ* & Medicamentorum effectus optime eruuntur.

The Laws of the Centripetal Force, *by Dr.* John Keill, n. 317. p. 174.

V. Cl. *Halleius*, Theorema, quo Lex Vis Centripetæ *Quantitatibus finitis* exhiberi poſſit, mecum communicavit; quod ipſi monſtravit D. *Abr. de Moivre*, dixitque D. *Newtonum* Theorema huic ſimile prius inveniſſe. Cum autem ejus demonſtratio perfacilis ſit, eam, itemque alia de eadem re cogitata, publico impertire volui.

Theorema.] *Si corpus Urgente vi Centripetâ in curva aliqua moveatur; Erit vis illa in quovis curvæ puncto, in ratione compoſita ex directâ ratione diſtantiæ corporis à centro virium, & reciproca ratione Cubi perpendicularis à Centro in rectam in eodem puncto Curvam Tangentem demiſſæ, ducti in Radium Curvaturæ quem ibi obtinet curva.*

Fig. 145.

Sit Q A O Curva quælibet à mobili urgente vi centripeta ad punctum S tendente deſcripta. Sitque A O arcus in minimo quovis tempore percurſus, P *m* ejus tangens, A R Radius circuli æquicurvi, hoc eſt cujus Peripheriæ pars minima cum Arcu A O coincidat. Et ſit S P recta à puncto S in tangentem perpendiculariter demiſſa; Ducantur O *m* ad S A & O *n* ad S P Parallelæ. Et exponat O *m* vim qua mobile in A urgetur verſus S. Vis qua perpendiculariter à tangente recedit corpus, erit ut O *n*, id eſt vis tendens verſus R & faciens ut mobile, eadem qua prius velocitate latum, deſcribet circulum æquicurvum arcui A O erit ad vim tendentem verſus S, qua corpus in curva A O movetur, ut O *n* ad O *m*, vel ob æquiangula triangula ut S P ad S A. Sed corporum in circulis latorum vires centripetæ ſunt ut quadrata velocitatum applicata ad Radios; per Corol. Theorem. 4. Princip. Newtoni. Eſt vero velocitas reciproce ut S P, ſive directe ut $\frac{1}{SP}$ adeoque quadratum velocitat. erit ut $\frac{1}{SP^2}$: vis igitur ut O *n*, ſive vis qua in circulo æquicurvo moveri poteſt corpus, erit ut $\frac{1}{SP^2 \times AR}$: Oſtenſum autem eſt, eſſe S P ad S A ut vis tendens verſus R, qua corpus in circulo æquicurvo moveri poteſt, ad vim tendentem verſus S: ſed eſt vis tendens verſus R ut $\frac{1}{SP^3 \times AR}$, adeo-

adeoque cum ſit $SP : SA :: \frac{1}{SP^2 \times AR} : \frac{SA}{SP^3 \times AR}$ erit vis tendens verſus S, ut $\frac{SA}{SP^3 \times AR}$. *Q. E. D.*

Fig. 146. *Cor.* Si curva QAO ſit circulus, erit vis centripeta tendens verſus S, ut $\frac{SA}{SP^3}$. Adeoque ſi vis centripeta tendat ad S punctum in circumferentia ſitum, erit [per 32 tertii] ang. PAS = ang. AQS; adeoque ob ſimilia triangula ASP, ASQ, erit AQ: AS :: AS: SP: unde $SP = \frac{AS^2}{AQ}$ & $SP^3 = \frac{AS^6}{AQ^3}$ unde $\frac{SA}{SP^3} = \frac{SA \times AQ^3}{AS^6} = \frac{AQ^3}{AS^5}$, hoc eſt, ob datum AQ, erit vis reciproce ut AS^5.

Fig. 147. Sit DAB, Ellipſis, cujus Axis DB, foci F & S, AR, OR duæ perpendiculares in curvam ſibi proximæ: ducantur KL, OT in SA, & KM in OR perpendiculares. Quia SA: SK :: (*) FA + SA: FS, hoc eſt data ratione, erunt rectarum SA, SK Fluxiones AT, K*k* ipſis SA, SK proportionales: & eſt AL = (†) ½ lateris Recti = ¼ L. Porro ob KA ad SP parallelam, eſt angulus ASP = KAL = TOA ob ang. TAO utriuſque complementum ad rectum: quare KA: AL :: SA: SP, unde $SP = \frac{L}{2} \times \frac{SA}{KA}$ & $KA = \frac{L \times SA}{2\,SP}$,

Porro ob æquiangula triang. KM*k*, GPS & OTA, SPA.

Eſt KM: K*k* :: GP: GS :: AP: SK
Item K*k*: AT :: SK: SA
Item AT: AO :: AP: SA

Erit KM: AO :: AP^2: SA^2 :: $SA^2 - SP^2$: SA^2 :: $SA^2 - \frac{L^2 \times SA^2}{4\,AK^2}$: SA^2 :: $4\,AK^2 - L^2$: $4\,AK^2$, unde L^2: $4\,AK^2$ :: (AO − KM: AO ::) AK: AR ac proinde $AR = \frac{4\,AK^3}{L^2}$. Eodem prorſus ratiocinio Invenietur Radius Curvaturæ in Hyperbola æqualis $\frac{4\,AK^3}{L^2} = \frac{L \times SA^3}{2\,SP^3}$.

Fig. 148. In Parabola vero facilior eſt calculus. Nam ob datam ſubnormalem, eſt K*k* ſemper = AT = Fluxioni Axis; & triangula K*k*M, ATO, SPA, AKL, æquiangula, unde KM: K*k* :: AP: SA, item eſt AT vel K*k*: AO :: AP: SA unde KM: AO :: AP^2 : SA^2 :: $SA^2 - SP^2$: SA^2 :: unde erit SP^2 : SA^2 :: AO − KM: AO :: AK: AR, ac proinde $AR = \frac{SA^2 \times AK}{SP^2}$; ſed

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(*) *Prop.* 3. *El.* 6*ti.* (†) *Prop.* 6. *partis* 4*tæ Sect. Con. Milnii.*

eſt

eſt $AL = \frac{1}{2}$ lateris Recti $= \frac{1}{2} L$, & $AK : AL :: SA : SP$, quare erit $\frac{L}{2} \times \frac{SA}{AK} = SP$, & $SP^2 = \frac{L^2 \times SA^2}{4 AK^2}$, quare erit $AR = \frac{4 AK^3}{L^2}$, vel quoniam eſt, $AK = \frac{L \times SA}{2 SP}$, erit $AR = \frac{L \times SA^3}{2 SP^3}$.

Atque ex his facillima oritur Conſtructio, pro determinando Radio Curvaturæ in quavis Sectione conica. Sit enim AK perpendicularis in Sectionem occurrens Axi in K, ex K ſuper AK erigatur perpendicularis HK, cum AS producta concurrens in H. Ex H erigatur ſuper AH, perpendicularis HR, erit AR Radius Curvaturæ. In Parabola paulo ſimplicior adhuc evadit Conſtructio. Nam quoniam ex natura Parabolæ eſt $SA = SK$, & ang. AKH rectus, erit S centrum Circuli per AKH tranſeuntis, unde invenitur Radius Curvaturæ producendo SA in H, ut $SH = SA$, & in H erigendo perpendicularem HR; Et R erit centrum Circuli oſculantis Parabolam in A. Fig. 149.

Vis centripeta, tendens ad focum Sectionis conicæ, in qua corpus movetur, eſt reciprocè proportionalis quadrato diſtantiæ. Nam quoniam $AR = \frac{L \times SA^3}{2 SP^3}$ erit $\frac{AR}{SP^3 \times AR} = \frac{SA \times 2 SP^3}{SP^3 \times L \times SA^3} = \frac{2}{L \times SA^2}$ hoc eſt ob datam $\frac{2}{L}$ erit vis centripeta ut $\frac{1}{SA^2}$.

Sit Ellipſis BAD, quam tangit in A recta GE. Sintque SP per Centrum Ellipſis & KA per contactum, tranſeuntes, perpendiculares in Tangentem. Erit $SP \times KA =$ quartæ parti figuræ Axis ſeu $=$ Quadrato ſemiaxis minoris $= BO \times DE$. Nam ob æquiangula Triang. GBO, GLA, GAK, GPS & GDE, Fig. 150.

$$\begin{array}{ccccc} SP : SG & :: & & & BO : GO \\ SG : DG & :: & BG : LG & :: & GO : GA \\ DG : DE & :: & & & GA : AK \end{array}$$

unde $SP : DE :: BO : AK$; & $SP \times AK = DE \times BO = \frac{1}{2} L \times SB$.

Hinc ſi Mobile moveatur in Ellipſi, vi centripeta tendente ad Centrum Ellipſis, erit vis illa directe ut diſtantia; Nam eſt $\frac{SP^3 \times 4 AK^3}{L^2}$ $=$ datæ Quantitati. Quia eſt $SP \times AK$ Quantitas data. Vis igitur, ut $\frac{SA}{SP^3 \times AR}$, erit ut SA diſtantia.

In figura 147 demiſſa ab altero umbilico F; in Tangentem Perpendiculari FI. ob æquiangula Triangula SAP, FAI, erit $SA : SP :: FA : FI = \frac{SP \times FA}{SA}$ unde erit $SP \times FI = \frac{SP^2 \times FA}{SA}$ $=$ Quadrato Fig. 147.

drato ſemiaxis minoris: unde ſi Axis major vocetur b, minor autem $2d$, erit $SP^2 = \frac{d^2 SA}{b - SA}$ & $SP = \frac{dSA^{\frac{1}{2}}}{\sqrt{b - SA}}$.

In Hyperbola autem eſt $SP = \frac{dSA^{\frac{1}{2}}}{\sqrt{b + SA}}$.

In Parabola eſt $SP = \sqrt{dSA}$, poſito ejus latere recto $= 4d$. Quoniam eſt $TA^2 : TO^2 :: AP^2 : SP^2 :: SA^2 - SP^2 : SP^2$ $:: SA^2 - \frac{d^2 SA}{b-SA} : \frac{d^2 SA}{b-SA} :: SA - \frac{d^2}{b-SA} : \frac{d^2}{b-SA} :: bSA - SA^2 - d^2 : d^2$, erit $\sqrt{bSA - SA^2 - d^2} : d :: TA : TO$, cumque fit $TA = SA$, erit $TO = \frac{dS\dot{A}}{\sqrt{bSA - SA^2 - d^2}}$.

Sit jam QAO quælibet curva, cujus arcus minimus ſit AO, tangentes in punctis A & O, AP, Op. Radius Curvaturæ AR, perpendiculares in tangentes ſint SP, Sp, erit $\frac{SA \times TA}{fP} = AR$. Nam ob æquiangula triangula eſt $fP : AO :: PA : RA$; & $AO : TA :: SA : PA$; unde ex æquo erit $fP : TA$ vel $S\dot{A} :: SA$ $: RA$; eſt vero $fP = S\dot{P}$, quare erit $RA = \frac{SA \times S\dot{A}}{S\dot{P}}$.

Fig. 151.

Hinc ſi diſtantia SA, in ſuam Fluxionem ducatur, & dividatur per Fluxionem perpendicularis, habebitur radius Curvaturæ: Quo Theoremate facile determinatur Curvatura in Radialibus Curvis. Exempli Gratia. Sit AQ, Spiralis Nautica; quoniam angulus SAP datur, ratio quoque SA ad SP dabitur; ſit illa ratio a ad b, erit $SP = \frac{bSA}{a}$ & $S\dot{P} = \frac{bS\dot{A}}{a}$ & $AR = \frac{SAS\dot{A}}{S\dot{P}} = \frac{aSA}{b}$, unde facile conſtabit, Spiralis Nauticæ evolutam eſſe eandem Spiralem, in alia poſitione.

Quoniam $AR = \frac{SAS\dot{A}}{S\dot{P}}$, erit $\frac{SA}{SP^3 \times AR} = \frac{SP}{SP^3 \times S\dot{A}}$. Atque hinc rurſus, ex data relatione SA ad SP, facile invenietur lex vis Centripetæ.

Fig. 152.

Exemplum. Sit VAB Ellipſis, cujus Focus S, Axis major $VB = b$, Axis minor $= 2d$, latus Rectum $2R$. Sitque VaQ alia Curva, ita ad hanc relata, ut ſit perpetuo angulus VSA angulo VSa proportionalis,

nalis, & ſit $SA = SA$. Quæritur lex vis Centripetæ tendentis ad S, qua corpus in curva VaQ moveri poteſt.

Quoniam ang. VSA eſt ad VSa, in data ratione; horum angulorum incrementa erunt in eadem ratione, ſitque ea ratio m ad n; unde erit $ot = \frac{n \times OT}{m}$. Eſt autem $OT = \frac{d\,S\dot{A}}{\sqrt{b\,SA - SA^2 - d^2}}$ unde erit $ot = \frac{n\,d\,S\dot{A}}{m\sqrt{b\,SA - SA^2 - d^2}}$.

Quoniam autem eſt $SA^2 + SP^2 : SP^2 :: ta^2 + ot^2 : ot^2 :: S\dot{A}^2 + \frac{n^2 d^2 S\dot{A}^2}{m^2 \times b\,SA - SA^2 - d^2} : \frac{n^2 d^2 S\dot{A}^2}{m^2 \times b\,SA - SA^2 - d^2} :: 1 + \frac{n^2 d^2}{m^2 \times b\,SA - SA^2 - d^2} : \frac{n^2 d^2}{m^2 \times b\,SA - SA^2 - d^2} :: m^2\,b\,SA - m^2\,SA^2 - m^2\,d^2 + n^2\,d^2 : n^2\,d^2$, unde erit $\sqrt{m^2\,b\,SA - m^2\,SA^2 - m^2\,d^2 + n^2\,d^2} : n\,d :: SA : SP$, & $SP = \frac{n\,d\,SA}{\sqrt{m^2\,b\,SA - m^2\,SA^2 - m^2\,d^2 + n^2\,d^2}}$

Cujus ut habeatur fluxio pro $m^2\,b\,SA - m^2\,SA^2 - m^2\,d^2 + n^2\,d^2$. Scribatur x & erit $SP = \frac{n\,d\,SA}{\sqrt{x}}$ & $SP^3 = \frac{n^3\,d^3\,SA^3}{x^{\frac{3}{2}}}$; & eſt $\dot{x} = m^2\,b\,SA - 2\,m^2\,SA\,S\dot{A}$, & $S\dot{P} = n\,d\,S\dot{A} \times x^{-\frac{1}{2}} - \frac{1}{2}\frac{n\,A\,SA\,\dot{x}}{x^{\frac{3}{2}}}$, & reducendo partes ad eundem denominatorem; erit $S\dot{P} = \frac{n\,d\,S\dot{A}\,x - \frac{1}{2}n\,d\,SA\,\dot{x}}{x^{\frac{3}{2}}}$. Et in numeratore loco, x & $\dot{x}$ ponendo ipſorum valores, & ordinando fit $SP = \frac{n\,d\,S\dot{A} \times \frac{1}{2}m^2\,b\,SA - m^2\,d^2 + n^2\,d^2}{x^{\frac{3}{2}}}$ unde erit $\frac{S\dot{P}}{SP^3 \times S\dot{A}} = \frac{\frac{1}{2}m^2\,b\,SA - m^2\,d^2 + n^2\,d^2}{n^2\,d^2\,SA^3}$. Sed eſt $\frac{S\dot{P}}{SP^3 \times S\dot{A}}$ ut vis Centripeta, quare erit vis, ut $\frac{\frac{1}{2}m^2\,b\,SA - m^2\,d^2 + n^2\,d^2}{n^2\,d^2\,SA^3}$ vel ob datam $n^2\,d^2$ in denominatore erit vis, ut $\frac{\frac{1}{2}m^2\,b\,SA - m^2\,d^2 + n^2\,d^2}{SA^3}$,

vel loco d^2 ponendo $\frac{bR}{2}$ erit vis ut $\frac{\frac{1}{8}m^2 bSA - \frac{1}{2}m^2 bR + \frac{1}{2}n^2 bR}{SA^3}$, ſeu ob datam $\frac{b}{2}$, ut $\frac{m^2 SA - Rm^2 + Rn^2}{SA^3} = \frac{m^2}{SA^2} + \frac{Rn^2 - Rm^2}{SA^3}$. Quæ omnia exactè coincidunt cum iis, quæ à D. *Newtono* de vi centripeta corporis in eadem Curva moti, traduntur, in *Prop.* 44. *Princip.*

Quoniam vis centripeta tendens ad punctum S, qua urgente corpus in Curva moveri poteſt, eſt ſemper ut $\frac{S\dot{P}}{SP^3 \times S\dot{A}}$; hinc ex data lege vis centripetæ, inveniri poteſt Relatio SA ad SP, ac proinde per methodum Tangentium Inverſam, exhiberi poteſt Curva, quæ data vi centripeta deſcribi poſſit.

Sit, verbi gratia, vis reciprocè ut diſtantiæ Dignitas quælibet m, hoc eſt, ſit $\frac{S\dot{P}}{SP^3 \times S\dot{A}} = \frac{b}{a^2 SA^m}$, erit $\frac{S\dot{P}}{SP^3} = \frac{bS\dot{A}}{a^2 SA^m}$, & capiendo harum fluxionum Fluentes; erit $\frac{1}{3} SP^{-2} = \frac{bSA^{1-m} \mp e}{m-1 \times a^2}$, unde erit $\frac{\frac{m-1}{2} \times a^2}{bSA^{1-m} \mp e} = SP^2$, & multiplicando tam Numeratorem, quam Denominatorem Fractionis, per SA^{m-1} & loco $\frac{m-1}{1} a^2$ ponendo d^2, fit $\frac{d^2 SA^{m-1}}{b \mp e SA^{m-1}} = SP^2$; quare erit $SP = \frac{d\sqrt{SA^{m-1}}}{\sqrt{b + eSA^{m-1}}}$.

Quod ſi Quantitas conſtans e ſit nihilo æqualis erit $SP = \frac{d\sqrt{SA^{m-1}}}{\sqrt{b}}$.

Adeoque, ſi vis reciproce, ut diſtantiæ Quadratum, poni poteſt $SP = \frac{\sqrt{d^2 SA}}{\sqrt{b}}$, & Curva erit Parabola, cujus latus rectum eſt ——,

$\frac{4d^2}{b}$, vel poteſt eſſe $SP = d \times \frac{\sqrt{SA}}{\sqrt{b - SA}}$ & Curva erit Ellipſis; vel denique poteſt eſſe $SP = d \times \frac{\sqrt{SA}}{\sqrt{b + SA}}$, & Curva evadit Hyperbola.

Si vis ſit reciprocè ut diſtantiæ Cubus ſupponi poteſt, ut SP ſit $= \frac{dSA}{b}$, & Curva fit Spiralis Nautica, vel fieri poteſt ut ſit SP $= \frac{dSA}{\sqrt{b - eSA^2}}$, & Curva erit eadem cum eâ, cujus conſtructionem à Sectore Hyperbolæ petit Dominus Newtonus; vel poteſt eſſe SP $= \frac{dSA}{\sqrt{b + eSA^2}}$, & ejus Curvæ conſtructionem per Sectores Ellipticos tradit idem Newtonus, *Cor.* 3. *Prop.* 1. *lib.* 1. *Princip.*

Si vis centripeta ſit reciprocè ut diſtantia; relatio inter SA & SP, Æquatione Algebraica definiri nequit, Curva tamen per Logarithmicam vel per quadraturam Hyperbolæ conſtruitur; fit enim $SP = \frac{d}{\sqrt{b - L.SA}}$, ubi L. SA deſignat Logarithmum ipſius SA.

Hæc omnia ſequuntur ex celebratiſſima nunc dierum Fluxionum Arithmeticâ, *quam ſine omni dubio primus invenit* D. Newtonus, *ut, cuilibet ejus* Epiſtolas *à* Walliſio *editas legenti, facile conſtabit: eadem tamen Arithmetica poſtea mutatis nomine & notationis modo, à* D. Leibnitio *in* Actis Eruditorum *edita eſt.*

Moveatur jam corpus in Curva QAO, urgente vi centripeta tendente ad S; & celeritas corporis in A dicatur C; celeritas autem qua corpus, urgente eadem vi centripeta, in eadem diſtantia, in Circulo moveri poteſt, dicatur *c*. Conſtat ex Theoremate primo, quod ſi SA exponat vim centripetam tendentem ad S; vis centripeta tendens ad R, qua urgente, corpus cum celeritate C, Circulum cujus Radius eſt AR deſcribet, per SP exponetur. Corporum autem Circulos deſcribentium, vires centripetæ ſunt, ut velocitatum quadrata ad Circulorum Radios applicata, quare erit $SP : SA :: \frac{C^2}{AR} : \frac{c^2}{SA}$, unde erit $SP \times AR : SA^2 :: C^2 : c^2$ & $C : c :: \sqrt{SP \times AR} : SA$. Fig. 145.

Si SP cum SA coincidat, ut fit in figurarum verticibus erit $C : c :: \sqrt{AR} : \sqrt{SA}$. Quod ſi Curva ſit Sectio conica AR; Radius Curvatu-

ræ in ejus vertice eſt æqualis dimidio lateris recti $= \frac{1}{2}$ L, ac proinde erit velocitas corporis in vertice Sectionis, ad velocitatem corporis in eadem diſtantia Circulum deſcribentis, in dimidiata ratione lateris recti, ad diſtantiam illam duplicatam.

Quoniam eſt $AR = \frac{SA \times S\dot{A}}{S\dot{P}}$, erit $C^2 : c^2 :: \frac{SP \times SA \times S\dot{A}}{S\dot{P}} : SA^2 :: \frac{SP \times S\dot{A}}{S\dot{P}} : SA :: SP \times S\dot{A} : SA \times S\dot{P}$, adeoque ex data relatione SP ad SA, dabitur ratio C ad c. Exempli gratia. Si vis ſit reciproce ut diſtantiæ dignitas m, hoc eſt ſit $\frac{S\dot{P}}{SP^3 \times S\dot{A}} = \frac{b}{a^2 SA^m}$: & erit $S\dot{P} = \frac{bSP^3 \times S\dot{A}}{a^2 SA^m}$, adeoque erit $C^2 : c^2 :: SP \times S\dot{A} : \frac{bSP^3 \times SA \times S\dot{A}}{a^2 SA^m} :: a^2 SA^{m-1} : bSP^2$. Unde ſi ponatur $SP^2 = \frac{d^2 SA^{m-1}}{b} = \frac{m-1}{2} \frac{a^2 SA^{m-1}}{b}$, erit $C^2 : c^2 :: a^2 SA^{m-1} : \frac{m-1}{2} a^2 SA^{m-1} :: m-1 : 2$ ac proinde erit $C : c :: \sqrt{2} : \sqrt{m-1}$.

Quod ſi ponatur $SP^2 = \frac{d^2 SA^{m-1}}{b - eSA^{m-1}} = \frac{m-1}{2} \frac{a^2 SA^{m-1}}{b - eSA^{m-1}}$ fiet C^2 ad c^2, ut $a^2 SA^{m-1}$ ad $\frac{\frac{m-1}{2} a^2 bSA^{m-1}}{b - eSA^{m-1}}$, hoc eſt ut $b - eSA^{m-1}$ ad $\frac{m-1}{2} b$, ſed eſt ratio $b - eSA^{m-1}$, ad $\frac{m-1}{2} \times b$, minor ratione b ad $\frac{m-1}{2} b$, ſeu ratione 2 ad $m-1$, unde erit C ad c in minore ratione quam eſt $\sqrt{2}$ ad $\sqrt{m-1}$.

Similiter, ſi capiatur $SP = \frac{d^2 SA^{m-1}}{b + eSA^{m-1}}$, invenietur eſſe C ad c in majore ratione quam eſt $\sqrt{2}$ ad $\sqrt{m-1}$.

Cor. Si corpus in Parabola moveatur, & vis centripeta tendat ad focum S, erit velocitas corporis, ad velocitatem corporis in eâdem diſtantiâ, circulum deſcribentis ubique ut $\sqrt{2}$ ad 1, nam in eo caſu eſt $m = 2$ & $m - 1 = 1$. Velocitas corporis in Ellipſi eſt ad velocitatem corporis,

corporis, in circulo ad eandem diſtantiam moti, in minore ratione quam $\sqrt{2}$ ad 1. Velocitas in Hyperbola eſt ad velocitatem in circulo in majore ratione, quam $\sqrt{2}$ ad 1.

Si Corpus in Spirali Nautica deferatur, eſt ejus velocitas ubique æqualis velocitati corporis in eadem diſtantia Circulum deſcribentis; nam in eo caſu eſt $m = 3$ & $m - 1 = 2$.

Problema.] *Poſito quod vis Centripeta (cujus quantitas abſoluta nota eſt,) ſit reciproce ut diſtantiæ quadratum, & projiciatur corpus ſecundum datam rectam cum data velocitate; Invenire Curvam in qua movetur Corpus.*

Projiciatur Corpus ſecundum datam rectam AB, cum data velocitate C. Et quoniam quantitas abſoluta vis Centripetæ nota eſt, dabitur inde velocitas, qua Corpus poſſit Circulum ad diſtantiam SA deſcribere urgente eadem vi; eſt enim æqualis ei quæ acquiritur, dum Corpus vi illâ uniformiter applicata urgente, cadit per $\frac{1}{2}$ SA. Sit illa velocitas *c*. Ex A in AB, erigatur perpendicularis AK, & in ea capiatur AR, quarta proportionalis ipſis c^2 C^2 & $\frac{SA^2}{SP}$ & erit AR, Radius curvaturæ in A. Ex R in AS demittatur perpendicularis RH & ex H in AR perpendicularis HK, & ducta recta SK, dabit axis poſitionem; Fiat angulus FAK = angulo SAK. Et ſi FA ſit ad SK Parallela, figura in qua movetur corpus erit Parabola. Si autem Axi SK occurrat in F; & puncta S & F, cadant ad eandem partem puncti K, figura erit Hyperbola; ſin ad contrarias partes cadant puncta S & F, erit Figura Ellipſis, unde focis S & F & Axe = SA $\pm$ FA deſcribetur Sectio, in qua Corpus movebitur.

Fig. 153.

VI. Nobiliſſimum eſt problema datâ lege vis Centripetæ invenire Curvam quam deſcribit Mobile, de loco dato, ſecundum datam rectam, & cum data velocitate egrediens. Conceſſis figurarum curvilinearum quadraturis, ejus ſolutionem perfectam olim dedit Dominus *Newtonus* in *Principiis Philoſophiæ Mathematicis*. Hoc ipſum Problema denuo aggreſſus eſt vir clariſſimus Dominus *Johannes Bernoulli* *, cujus ſolutionem cum *Newtoniana* comparavi; & hæc quæ ſequuntur annotavi.

Of the Inverſe Problem *of the* Laws *of the* Centripetal Force; *with Remarks on* Bernoulli, *by Dr.* John Keil, n. 340. p. 91. *Nov.* 24. 1713.

Dominus Bernoulli eandem præmittit propoſitionem, quam *Newtonus* problemati demonſtrando prius adhibuit: eſtque ea in *Principiis* XL, non minus pulchra quam demonſtratu facilis. Scil.

Si corpus cogente vi quacunque Centripeta moveatur utcunque, & corpus aliud recta aſcendat vel deſcendat, ſintque eorum velocitates, in aliquo æqualium altitudinum caſu, æquales; velocitates eorum in omnibus æqualibus altitudinibus erunt æquales.

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* Vide Commentarios Phyſico-mathematicos Pariſienſes Anno 1710.

Hujus

Hujus Propoſitionis Demonſtrationem *Newtonianam* ait *Bernoullius* eſſe nimis implicatam, & ſuam, quam ſimpliciorem vocat, ejus loco ſubſtituit. At pace tanti viri liceat mihi dicere, ſi quid diſcriminis ſit inter Demonſtrationem *Bernoullianam* & *Newtonianam*, id in eo ſitum eſt, quod hæc multo facilior eſſe videtur, minuſque perplexa quam
Fig. 154. illa. Nam ſi Centro *C* deſcribantur Circuli *DI*, *EK*, quorum intervallum *DE* eſt quam minimum, ſintque corporum in *D* & *I* velocitates æquales, & ab *N* ad *IK* demittatur perpendiculum *NT*, fuſe oſtendit *Newtonus* vim acceleratricem ſecundum *DE*, eſſe ad vim acceleratricem ſecundum *IK* ut *IN* ad *IT*. Nimirum ſi vis ſecundum *DE* vel *IN* exponatur per rectas *DE* vel *IN*, vis illa ſecundum *IN* reſolvitur in duas, *TI*, *TN*, quarum illa ſolum, quæ eſt ut *TI*, motum ſecundum Directionem *IK* accelerat: Acceleraciones autem ſeu velocitatum incrementa ſunt ut vires & tempora quibus generantur conjunctim. At tempora ob æquales velocitates in *D* & *I*, ſunt ut viæ deſcriptæ *DE*, *IK*; quare acceleraciones in decurſu corporum per lineas *DE* & *IK*, ſunt ut *DE* ad *IT* & *DE* ad *IK* conjunctim; *i. e.* ut *DE* quad. quod eſt *IN* quad. ad rectang. *IT* × *IK*, adeoque ob *IN* quad. = *IT* × *IK*, incrementa velocitatum ſunt æqualia: æquales igitur ſunt velocitates in *E* & *K*, & eodem argumento ſemper reperientur æquales in æqualibus diſtantiis. Hæc eſt ſumma Demonſtrationis *Newtoni*, quæ tam dilucide ab eo exponitur, ut inter Propoſitiones elementares paucas faciliores invenies. At non ſic procedit D. *Bernoullius*, ſed illi ſufficit dicere, Mechanicam oſtendere vim ſecundum *DE* eſſe ad vim ſecundum *IK*, ut *IK* ad *DE*. Mechanicam etiam oſtendere incrementa velocitatum eſſe in ratione virium & temporum conjunctim; & initio motus poſitis velocitatibus æqualibus tempora ſunt ut viæ deſcriptæ *DE*, *IK*; & hinc, (argumento prorſus ſimili ei quo utitur *Newtonus*) concludit incrementum velocitatis, quod acquirit corpus dum deſcribit *IK*, eſſe ad incrementum velocitatis dum deſcribitur *DE*, ut *DE* × *IK* ad *IK* × *DE*, & proinde velocitatum incrementa ubique in diſtantiis æqualibus eſſe æqualia.

At ſi Tyronibus facilem voluiſſet tradere Demonſtrationem, debuiſſet Propoſitionem Mechanicam citare, eamque ad præſentem caſum accommodare. Et quidem pluribus verbis opus eſt, ut hoc fiat Theorema quod innuere videtur, in quo agitur de deſcenſu Gravium in planis inclinatis: nullum enim eſt hic planum datum, quod recto corporum deſcenſui obſtat; immo tantum abeſt ut corpus à plano cohibeatur, ut è contra à Plano ſeu Tangente per vim quandam continuo retrahitur. Proculdubio igitur manifeſta magis foret ejus ratiocinii vis, ſi dimiſſis Mechanicæ Propoſitionibus, rem omnem ex propriis principiis demonſtraſſet, uti fecit *Newtonus*. Nam reſolvendo triang. rectang. *KNI* in duo triangula æquiangula, eſt *KI* ad *IN* ut *IN* ad *IT*, adeoque loco rationis *IN* ad *IT* ponere potuiſſet rationem *KI* ad *IN* vel ad *DE*.

Si

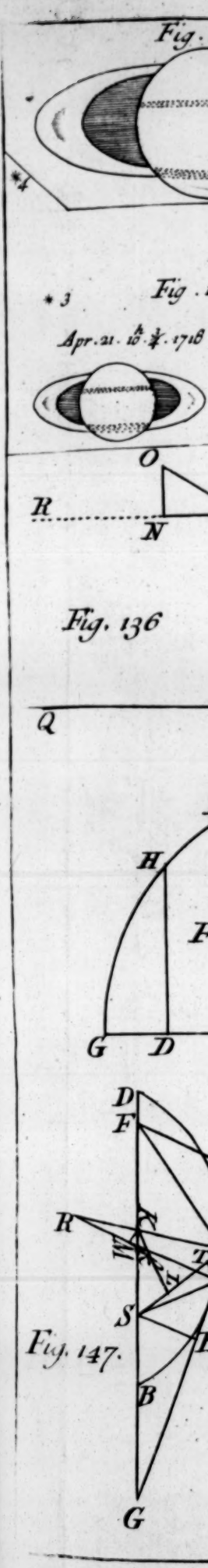


Fig. 147.

Fig. 134.

Fig. 132

Fig. 133.

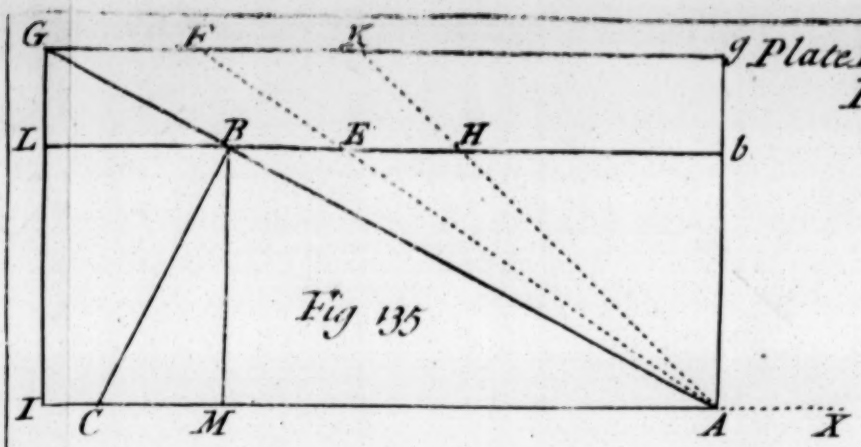
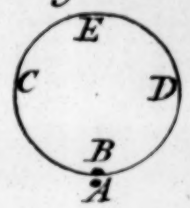


Fig 135

Fig 142



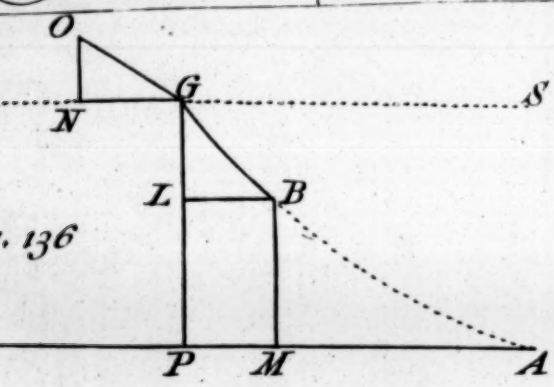


Fig. 136

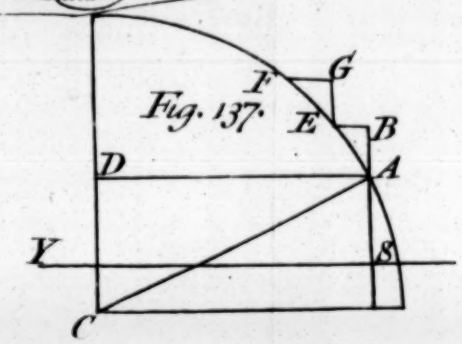


Fig. 137.

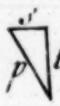


Fig. 138

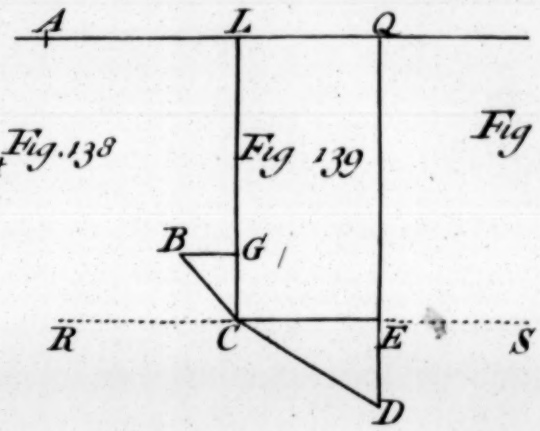


Fig 139

Fig 143

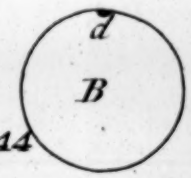


Fig. 144

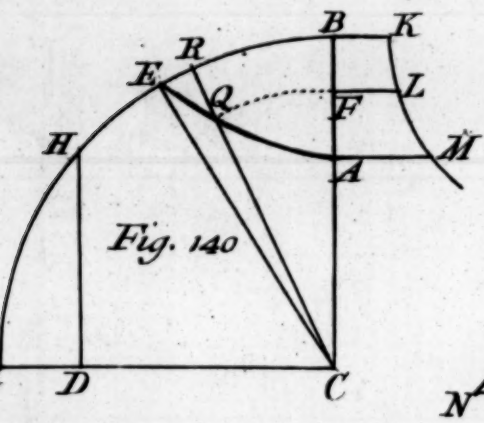


Fig. 140

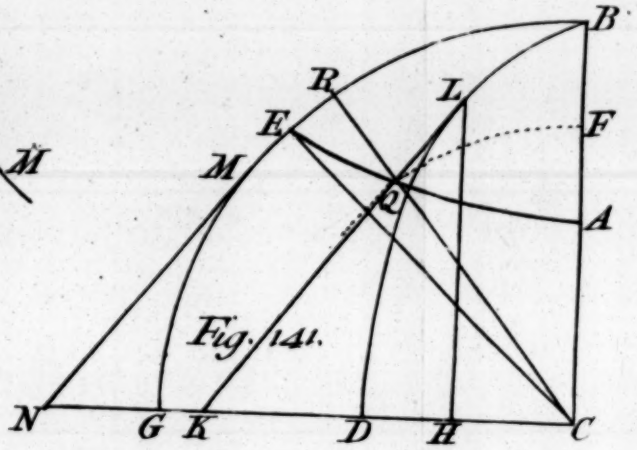


Fig. 141.

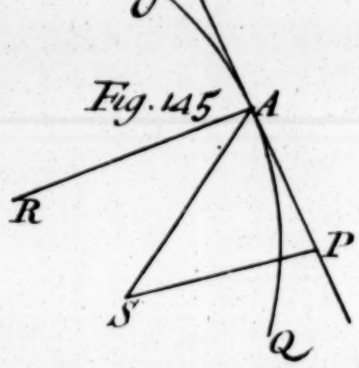


Fig. 145

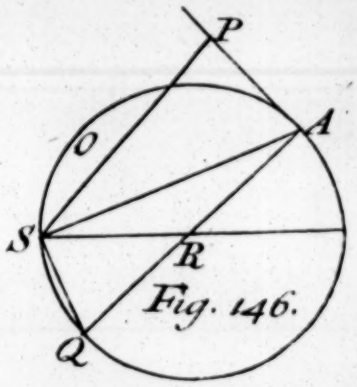
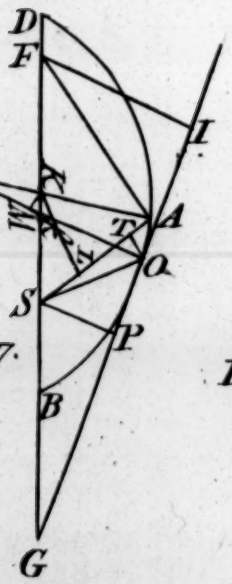


Fig. 146.



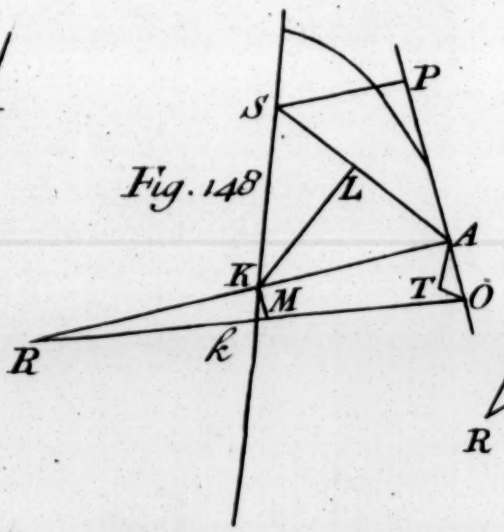


Fig. 148

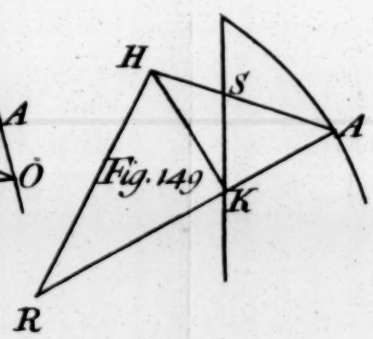


Fig. 149

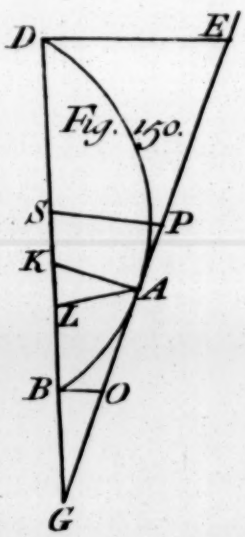


Fig. 150.

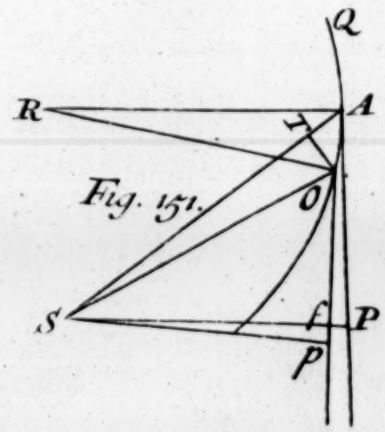


Fig. 151.

ج

Si de loco quovis A in recta AC cadat corpus, deque loco ejus E erigatur ſemper perpendicularis EG vi centripetæ proportionalis, ſitque BFG linea curva, quam punctum G perpetuo tangit; demonſtrat * *Newtonus* velocitatem corporis in loco quovis E eſſe ut Areæ curvilineæ $ABGE$ latus quadratum. Adeoque ſi velocitas dicatur v, erit v^2 ut Area $ABGE$: & ſi P ſit altitudo maxima, ad quam corpus in Trajectoria revolvens, deque quovis ejus puncto eâ, quam ibi habet, velocitate ſurſum projectum aſcendere poſſit: ſitque Quantitas A diſtantia corporis à centro, in alio quovis orbitæ puncto; & vis centripeta ſit ſemper ut ipſius A dignitas quælibet, ſcil. ut A^{n-1}, Velocitas corporis in omni altitudine A erit ut $\sqrt{nP^n - nA^n}$.

Similiter D. *Bernoullius* oſtendit, ſi diſtantia à Centro dicatur x, velocitas v & vis centripeta φ, eſſe $v = \sqrt{ab - \int \varphi \dot{x}}$: ubi ex Quadraturis conſtat eſſe Aream $ABGE = ab - \int \varphi \dot{x}$. Perinde itaque eſt, ſive exprimatur quadratum velocitatis per Aream $ABGE$, ſive per Quantitatem huic æqualem $ab - \int \varphi \dot{x}$. Et ſi vis centripeta φ ſit ut nA^{n-1} ſeu nx^{n-1}, fit $ab = P^n$ & $\int \varphi \dot{x} = A^n$, adeoque $ab - \int \varphi \dot{x}$ eſt ut Quantitas $P^n - A^n$.

Deſcribat corpus Curvam VK, vi centripeta tendente ad C, deturque Circulus VXY, Centro C intervallo quovis CV deſcriptus. $\mathcal{Q}$ ſit Quantitas conſtans, atque $\frac{\mathcal{Q}}{A} = z$. Sitque KI elementum Curvæ; IN vel DE elementum altitudinis, XI elementum arcus: demonſtrat *Newtonus* elementum arcus ſeu XY exprimi poſſe per hanc Formulam $\frac{\mathcal{Q} \times IN \times CX}{AA\sqrt{ABGE - z^2}}$ Similiter ex præmiſſis D. *Bernoullius*, poſito arcu $UX = z$, & altitudine ſeu diſtantia $= x$, elementum arcus ad hanc reducit Formulam ſcil. $\dot{z} = \frac{a^2 c \dot{x}}{\sqrt{ab x^4 - x^4 \int \varphi \dot{x} - a^2 c^2 x^2}}$. Et primo quidem aſpectu videbatur Formula *Newtoniana* quodammodo ſimplicior *Bernoulliană*, eo quod paucioribus conſtat terminis; at re diligentius exploratâ, vidi *Bernoullianam* Formulam omnino cum *Newtoniana* coincidere; nec niſi in notatione Quantitatum ab ea differre. Nam ſi pro $ab - \int \varphi \dot{x}$ ponatur $ABGE$, pro ac ponatur $\mathcal{Q}$, & x pro

* Vide Prop. 39 & 40. Principiorum.

A, a pro CX, & $\dot{x}$ pro IN, fit $\frac{a^2 c \dot{x}}{\sqrt{abx^4 - x^4 \int \varphi \dot{x} - a^2 c^2 x^2}} =$

$\frac{Q \times CX \times IN}{\sqrt{A^4 \times ABGE - \frac{Q^2 A^4}{A^2}}} = \frac{Q \times CX \times IN}{AA\sqrt{ABGE - Q^2}}$ ſeu ponendo z^2 loco $\frac{Q^2}{A^2}$, (quod facit Newtonus commodioris notationis gratia,) Formula Bernoulliana evadit $\frac{Q \times CX \times IN}{A^2\sqrt{ABGE - z^2}}$: unde conſtat Formulam illam non magis à Newtoniana diſcrepare, quam verba Latinis literis expreſſa differunt ab iiſdem verbis ſcriptis in Græcis characteribus.

Poſt traditam generalem Formulam, deſcendit D. *Bernoullius* ad caſum particularem, ubi vis centripeta eſt reciprocè ut quadratum diſtantiæ; & per varias Reductiones & Operationes ſatis moleſtas, Conſtructionem oſtendit Curvarum, quæ urgente eâ vi centripeta deſcribi poſſunt, eaſque ad Æquationes reducendo probat eſſe Sectiones conicas. Deinde queritur D. *Newtonum* ſupponere ſine Demonſtratione Curvas à tali vi deſcriptas eſſe Sectiones conicas.

Impoſſibile eſt, ut credat nullam *Newtono* notam fuiſſe hujus rei Demonſtrationem; Noverat enim; eum primum & ſolum fuiſſe qui hanc omnem de vi centripeta Doctrinam geometricè tractavit, quique eam ad tantam Perfectionem perduxit. Noverat etiam *Bernoullius Newtonum*, præter generalem Problematis inverſi Solutionem, oſtendiſſe modum quo formari poſſunt Curvæ, quæ vi centripeta decreſcente in triplicata diſtantiæ Ratione deſcribuntur, adeoque alterum illum caſum ignorare non potuiſſe. Nec profecto intelligo, qua Ratione *Bernoullius Newtono* objiciat, eum hujus caſus Demonſtrationem prætermiſiſſe; cum ipſe non pauca ſæpius propoſuit Theoremata, quorum Demonſtrationes nuſquam dedit; & quidni liceat *Newtono* ad alia feſtinanti hoc idem facere? Interim in nova *Principiorum* Editione, facilior multo & magis clara, licet tribus verbis, extat hujus rei Demonſtratio, quam eſt Bernoulliana.

Tandem *Bernoullius*, ut Neceſſitatem ſuæ Demonſtrationis inverſi Problematis in hoc particulari caſu oſtendat, hæc addit. Conſiderandum eſt, inquit, quod vis, quæ facit ut corpus in Spirali Logarithmica moveatur, debet eſſe reciprocè ut Cubus diſtantiæ a Centro; at non inde ſequitur talibus viribus ſemper deſcribi debere tales Curvas, cum ſimiles etiam vires facere poſſunt, ut Corpus in Spirali Hyperbolica moveatur.

Miror

Miror, ſane quod Vir Cl. ſuſpicetur *Newtonum* talem unquam duxiſſe conſequentiam. Nam præter Spiralem Logarithmicam, oſtendit *Newtonus*, qua Ratione aliæ Curvæ, numero infinitæ & diverſæ, formari poſſunt, quæ omnes deſcribantur eadem vi centripeta qua Spiralis Logarithmica; interque eas reponi debet hæc ipſa Spiralis Hyperbolica, ut in ſequentibus oſtendemus.

Exinde autem concludit *Newtonus* Sectiones tantum Conicas neceſſario deſcribi debere per vim centripetam quadrato diſtantiæ reciprocè proportionalem: Nempe quod Curvatura orbitæ cujuſcunque ex datis velocitate, vi centripeta & poſitione Tangentis datur; datis autem umbilico, puncto contactus & poſitione Tangentis ſemper deſcribi poſſit Sectio Conica quæ curvaturam illam datam habeat. Hoc à me prius oſtenſum eſt*. In hac igitur Sectione, urgente illa vi, corpus movebitur, & in nulla alia; cum corpus de eodem loco, ſecundum eandem Directionem, eadem cum velocitate, & urgente eadem vi centripeta exiens, non poſſit diverſas ſemitas deſcribere.

* Vid. Supra, S. V.

Liceat jam mihi D. *Bernoullium* imitari, & Inverſum de vi centripeta Problema longe diverſa methodo reſolvere, & ad caſum particularem applicare; ubi ſcil. vis eſt reciprocè ut Cubus diſtantiæ, ſimulque oſtendere Demonſtrationem Cor. 3. Prop. 41. *Principiorum* Newtoni.

Quod ut fita, quædam ex iis quæ ſupra † expoſui hic præmittenda ſunt.

† Vid. Supra, S. V.

Sit *VIL* Curva quævis, quam corpus urgente vi centripeta ad Centrum *C* tendente deſcribit: hanc Curvam in duobus punctis infinitè vicinis *I* & *K* tangat rectæ *IP*, *Kp*, ad quas è Centro demittantur perpendiculares *CP*, *Cf*; Centro item *C* deſcribantur *KE*, *ID*, & ducatur *CI*. Fig. 155.

Erit vis centripeta ut Quantitas $\frac{Pp}{PC^3 \times IN}$ Quod Theorema licet in prædicto loco demonſtravimus, ecce aliam ejus Demonſtrationem. Ex *K* ducantur *Km* ad *CP* & *Kn* ad *CI* parallelæ. Et ob æquiangula triangula *ICP*, *IKN*, *nKm*, Itemque ob *IKm* & *IpP* æquiangula. Erit

Ip vel *IP* : *IK* :: *pP* : *Km*
PC : *IP* :: *Km* : *mn*
IN : *IK* :: *mn* : *nK* unde ex æquo
fiet $PC \times IN : IK^2 :: pP : nK$, & erit $nK = \frac{pP \times IK^2}{PC \times IN}$. Præterea tempus quo deſcribitur arcus *IK* eſt ut Area ſeu triangulum *ICK*, vel ejus duplum $PC \times IK$; adeoque ſi tempus detur, erit $PC \times IK$ Quantitas conſtans. Dato autem tempore, vis centripeta eſt ut Lineola *Kn* quæ ſub urgente vi illa deſcribitur, adeoque vis centripeta eſt ut Lineola illa *Kn* ducta in Quantitatem conſtan-

tem $\frac{1}{PC^2 \times IK^2}$ hoc eſt, erit vis centripeta ut $\frac{1}{PC^2 \times IK^2} \times \frac{Pp \times IK^2}{PC \times IN}$ ſeu ut Quantitas $\frac{Pp}{PC^3 \times IN}$. Quod erat demonſtrandum.

Velocitas corporis in quovis loco eſt ut via in minimo quovis tempore percurſa directè, & ut tempus illud inversè; adeoque & ut $IK \times \frac{1}{PC \times IK}$, hoc eſt, velocitas erit reciprocè ut Perpendicularis è Centro in Tangentem.

Si diſtantia corporis à centro dicatur x, & Perpendicularis in Tangentem p, erit $IN = \dot{x}$ & $Pp = \dot{p}$ & vis centripeta exponi poteſt per Quantitatem $\frac{f^4 \dot{p}}{p^3 \dot{x}}$, aſſumendo Quantitatem quamlibet pro f^4.

Adeoque ſi cum Domino *Bernoullio* vim centripetam nominemus ϕ, erit $\frac{f^4 \dot{p}}{p^3 \dot{x}} = \phi$ & $\frac{f^4 \dot{p}}{p^3} = \dot{x}\phi$; & capiendo harum Quantitatum Fluentes erit $\frac{f^4}{2p^2}$ = Fluenti quantitatis $\dot{x}\phi$.

At cum velocitas corporis ſit reciprocè ut perpendicularis p, ejus quadratum exponi poteſt per $\frac{f^4}{2p^2}$. Si itaque velocitas dicatur v, erit $v^2 = \frac{f^4}{2p^2}$ = Fluenti quantitatis $\dot{x}\phi$. Quod ſi A ſit locus, de quo cadere debet corpus, ut acquirat in D vel I velocitatem v, deque loco corporis D erigatur perpendicularis $DF = \phi$ erit rectangulum $DE \times DF = \dot{x}\phi$. Sit jam BFG linea curva, cujus ordinatæ exponant vires centripetas, ſeu quantitates ϕ. Fluens quantitatis $\dot{x}\phi$ erit Area curvilinea $ABFD = v^2 = \frac{f^4}{2p^2}$, adeoque erit v ut Areæ $ABFD$ latus quadratum. Quod ſi velocitas ea ſit quæ ab infinita diſtantia cadendo

acquiritur, erit v^2 ſeu Fluens ipſius $\dot{x}\varphi$ æquale areæ $ODFO$ indefinitè protenſæ.

Hinc ſemper dabitur quantitas p in terminis finitis, quando Area illa curvilinea terminis finitis exponi poteſt. Sit, verbi gratia, vis centripeta reciprocè ut diſtantiæ dignitas m, hoc eſt, ſit $\dot{x}\varphi = \frac{g\dot{x}}{x^m}$. Si velocitas corporis ſit ea quæ acquiritur cadendo ab infinita diſtantia, erit $v^2 = \frac{g}{m-1 \times x^{m-1}} = \frac{f^4}{2p^2}$ & in hiſce omnibus caſibus Area indefinitè protenſa eſt quantitas finita. Poteſt autem corpus in trajectoria revolvi velocitate cujus quadratum vel majus fieri poteſt, vel minus quantitate $\frac{g}{m-1\,x^{m-1}}$, vel huic æquale. Adeoque erit $v^2 = \frac{f^4}{2p^2} = \frac{g}{m-1\,x^{m-1}} \pm e^2$.

Hinc urgentibus his viribus, tria Curvarum genera deſcribi poſſunt; prout e^2 eſt quantitas poſitiva, vel negativa, vel nulla.

V. G. Si velocitas major ſit ea quæ acquiritur ab infinita diſtantia cadendo, fit $\frac{f^4}{2p^2} = \frac{g}{m-1\,x^{m-1}} + e^2$: ſi velocitas ſit minor erit $\frac{f^4}{2p^2} = \frac{g}{m-1\,x^{m-1}} - e^2$: ſi æqualis, erit $\frac{f^4}{2p^2} = \frac{g}{m-1\,x^{m-1}}$.

Sit $\frac{1}{2} f^4 = a^2 e^2$ & $\frac{1}{m-1} \times g = b^2 e^2$. Et ſi velocitas corporis ſit ea quæ ab infinito cadendo acquiritur, erit $p^2 = \frac{a^2 x^{m-1}}{b^2}$ ſeu $p = \frac{a x^{\frac{m-1}{2}}}{b}$.

At ſi velocitas major ſit aut minor hac velocitate, fiet uti oſtenſum eſt $\frac{f^4}{2p^2} = \frac{g}{m-1\,x^{m-1}} \pm e^2 = \frac{\frac{1}{m-1} g \pm e^2 x^{m-1}}{x^{m-1}}$. Unde pro $\frac{1}{2} f^4$ & $\frac{g}{m-1}$ ponendo earum valores $a^2 e^2$ & $b^2 e^2$, erit $\frac{a^2 e^2}{p^2} = \frac{b^2 e^2 \pm e^2 x^{m-1}}{x^{m-1}}$

ſeu

ſeu $\frac{a^2}{p^2} = \frac{b^2 \pm x^{m-1}}{x^{m-1}}$, & fiet $p^2 = \frac{a^2 x^{m-1}}{b^2 \pm x^{m-1}}$.

Adeoque ſi vis centripeta ſit reciprocè ut cubus diſtantiæ, hoc eſt, ſi ſit $m = 3$ & $m - 1 = 2$. Erit $p^2 = \frac{a^2 x^2}{b^2}$, vel $p^2 = \frac{a^2 x^2}{b^2 + x^2}$, vēl denique $p^2 = \frac{a^2 x^2}{b^2 - x^2}$.

In primo caſu conſtat Curvam eſſe Spiralem Logarithmicam: nam ſit $p = \frac{a x}{b}$, & $b : a :: x : p$, adeoque ob conſtantem Rationem b ad a, erit angulus CIP ubique conſtans.

Ponamus jam eſſe $p^2 = \frac{a^2 x^2}{b^2 + x^2}$ & ex hac ſuppoſitione tres oriuntur diverſæ Curvarum ſpecies, prout a major eſt quam b, aut ei æqualis, aut minor.

Fig. 156. Et primo ſit a major quàm b. Centro C & ad diſtantiam quamvis datam deſcribatur Circulus $H\Upsilon X$, cui rectæ CK, CI productæ occurrant in Υ & X. Et eſt $IN^2 : KN^2 :: IP^2 : PC^2$ & ita $CI^2 - PC^2 :$ $PC^2 :: x^2 - p^2 : p^2 :: x^2 - \frac{a^2 x^2}{b^2 + x^2} : \frac{a^2 x^2}{b^2 + x^2} :: 1 - \frac{a^2}{b^2 + x^2} : \frac{a^2}{b^2 + x^2}$ $:: b^2 + x^2 - a^2 : a^2$. Quare erit $\sqrt{x^2 + b^2 - a^2} : a :: IN : KN$ $: \dot{x} : \frac{a\dot{x}}{\sqrt{x^2 + b^2 - a^2}} = KN$. Et quoniam eſt a major quam b, erit $b^2 - a^2$ Quantitas negativa. Sit illa $-c^2$, unde fit $KN = \frac{a\dot{x}}{\sqrt{x^2 - c^2}}$ dicatur Radius Circuli $H\Upsilon b$, & eſt $CK : KN :: C\Upsilon : \Upsilon X$ hoc eſt $x : \frac{a\dot{x}}{\sqrt{x^2 - c^2}} :: b : \frac{ba\dot{x}}{x\sqrt{x^2 - c^2}} = \Upsilon X = \dot{y}$, ſi arcus $H\Upsilon$ vocetur y.

Sit $x = \frac{c^2}{z}$ unde $\dot{x} = -\frac{c^2 \dot{z}}{z^2}$ & $\frac{\dot{x}}{x} = -\frac{\dot{z}}{z}$. Item erit $x^2 - c^2$

$=$

$= \frac{c^4}{z^2} - c^2 = \frac{c^4 - c^2 z^2}{z^2} = \frac{c^2}{z^2} \times \overline{c^2 - z^2}$: unde $\sqrt{x^2 - c^2} = \frac{c}{z} \times$ $\sqrt{c^2 - z^2}$: quibus valoribus ſubſtitutis, erit $\frac{b a \dot{x}}{x\sqrt{x^2 - c^2}} = \frac{-b a \dot{z}}{c\sqrt{c^2 - z^2}}$.

Sit $a : c :: n : 1$. hoc eſt, ſit $a = nc$, & fiet XY ſeu $\dot{y} = -\frac{n b \dot{z}}{\sqrt{c^2 - z^2}}$.

Eſt verò $\frac{n b \dot{z}}{\sqrt{c^2 - z^2}}$ ad $\frac{c \dot{z}}{\sqrt{c^2 - z^2}}$ ut nb ad c; hoc eſt in Ratione data: adeoque eorum Fluentes, ſi ſimul incipiunt, erunt in eadem Ratione, hoc eſt erit HY ſeu y ad Fluentem Quantitatis $\frac{cz}{\sqrt{c^2 - z^2}}$ ut nb ad c.

Quod ſi Centro C radio $CV = c$ deſcribatur Circulus VL, & CG ſit $= z$, & $no = \dot{z}$, fiet arcus $mn = \frac{c \dot{z}}{\sqrt{c^2 - z^2}} =$ Fluxioni arcus $\mathcal{Q}m$, quando Fluxio eſt Quantitas poſitiva: ſed quando eſt negativa, ejus Fluens eſt arcus Vm prioris complementum. Arcus enim ejuſque complementum eandem habent Quantitatem Fluxionem denotantem, diverſis tantum ſignis affectam; quia creſcente uno decreſcit alter.

Hinc eſt HY ad Vm ut nb ad c: ſed eſt CV ad CH ut $Ve : HY$, hoc eſt $c : b :: Ve : \frac{b \times Ve}{c} = HY$, quare erit $\frac{b \times Ve}{c} : Vm :: nb : c$, unde $Ve : Vm :: n : 1$.

Præterea ex natura Circuli erit $CG : CV :: CV : C\mathcal{T}$, quando $m\mathcal{T}$ Circulum tangit: hoc eſt erit $z : c :: c : \frac{c^2}{z} = C\mathcal{T} = x$. Hinc ſi capiatur angulus VCe ad angulum VCm ut n ad 1, & producatur Ce ad K ut ſit $CK =$ ſecanti $C\mathcal{T}$, erit K punctum in Curvâ quæſitâ.

Hic obiter notandum eſt, ſi n ſit numerus, hoc eſt ſi ſit a ad c vel a ad $\sqrt{a^2 - b^2}$ ut numerus ad numerum, Curva VI fiet Algebraica: nam in hoc caſu relatio mG ad ſinum anguli VCe Æquatione definitur, & inde habebitur relatio ſinus anguli VCe ad $C\mathcal{T}$ vel CK per Æquationem determinatam, & inde demum dabitur Æquatio quæ exprimet Relationem inter ordinatam & interceptam à puncto C incipientem.

Harum Curvarum ordines & gradus in Scala Æquationum Algebraica diverſi erunt pro magnitudine numeri n. In his omnibus Curvis ſic deſcriptis Aſymptoti poſitio hac ratione determinatur: Fiat angulus VCL ad rectum angulum ut n ad 1. In eo angulo diſtantia corporis à Centro evadit infinita. Jam quad. perpendicularis in Tangentem $PC = \frac{a^2 x^2}{b^2 + x^2}$ ubi x eſt infinita, fit $PC^2 = \frac{a^2 x^2}{x}$, ſeu $PC = a$. Ducatur itaque CR ad CL perpendicularis & æqualis rectæ a, & ſi per R ducatur RS rectæ CL parallela, hæc Curvam tanget ad infinitam diſtantiam, ſeu erit Curvæ Aſymptotos.

Si corpus in quavis harum Curvarum deſcendendo, ad Apſidem imam pervenerit; Hinc rurſus aſcendet in infinitum, & aliam Curvam priori ſimilem, ſeu potius ejuſdem Curvæ ſimilem portionem, aſcendendo deſcribet.

Curvæ hæ poſſunt pluribus revolutionibus circa Centrum torqueri, priuſquam ad Aſymptoton convergere incipiant, & motus angularis rectæ CK erit æqualis totidem rectis quot numerus n conſtat Unitatibus. *v. g.* ſi n ſit 100, perficientur viginti quinque integræ revolutiones, priuſquam diſtantia à Centro evadat infinita.

Aucto numero n, eadem manente a, minuitur c: eſt enim $\frac{a}{n} - c$ & $\frac{a^2}{n^2} = c^2 = a^2 - b^2$, unde fiet $\overline{n^2 - 1} \times a^2 = n^2 b^2$. Et proinde fiet $a^2 : b^2 :: n^2 : n^2 - 1$; adeoque ſi b^2 ad æqualitatem accedat ipſius a^2, perveniet quoque $n^2 - 1$ ad rationem æqualitatis cum n^2, & proinde augebitur n & in eadem ratione minuetur c. Ponatur itaque eſſe b^2 fere æquale ipſi a^2; adeo ut cum differentia ſit infinite parva, fiat n numerus infinite magnus, & Radius Circuli c fiet infinite parvus, ſeu Circulus in ſuum Centrum contrahetur. At ſic evaneſcente c, non pariter evaneſcit CT, ſi angulus VCM ſit propemodum rectus: nam in omni Circulo, etiam minimo, ſecans anguli recti eſt Quantitas infinita. Curva itaque hæc, ob n numerum infinitum, infinitis numero revolutionibus Centrum ambibit, priuſquam ad Aſymptoton convergere incipiet.

Evaneſcente autem c fit $b = a$ & $p = \frac{a x}{\sqrt{x^2 + a^2}}$. Et quoniam in omni caſu eſt $\dot{y} = \frac{b a \dot{x}}{x\sqrt{x^2 + c^2}}$, evaneſcente c fiet $\dot{y} = \frac{b a \dot{x}}{x^2}$, unde capien-

do

do Fluentes fiet $y = \frac{ba}{x}$ ſeu $xy = ba =$ datæ quantitati.

Hæc Curva eſt Spiralis hyperbolica, quæ plures habet notabiles proprietates. Si ducatur radius quilibet $CI\Upsilon$ Curvæ occurrens in I, & Peripheriæ circuli in Υ, & ex C ad CI excitetur perpendicularis $C\mathcal{T}$, atque $I\mathcal{T}$ tangat Curvam in I, & rectæ $C\mathcal{T}$ occurrat in $\mathcal{T}$: erit $C\mathcal{T}$ conſtans recta, æqualis ſcil. arcui VE; qua Proprietate Logarithmicam æmulatur, cum $C\mathcal{T}$ Curvæ ſubtangens dici poſſit. Sit enim Radius circuli $CE = b$, arcus $VE = a$, dicatur $CI\,x$ & $V\Upsilon$ ſit y. Quia eſt $ba = xy$ erit $\frac{ba}{x} = y$ & $\frac{ba\dot{x}}{x^2} = \dot{y}$. Porro eſt $C\Upsilon : CI :: \Upsilon X : NK$ hoc eſt $b : x :: \frac{ba\dot{x}}{x^2} : NK$: quæ proinde eſt $\frac{a\dot{x}}{x}$. Et quoniam eſt $IN : NK :: CI : C\mathcal{T}$. hoc eſt $\dot{x} : \frac{a\dot{x}}{x} :: x : C\mathcal{T}$, erit $C\mathcal{T} = a$.

Si centro C, intervallo quovis CG, deſcribatur circuli arcus GF, hic arcus inter rectam CV & Curvam interceptus erit ſemper æqualis conſtanti rectæ $C\mathcal{T}$ vel a. Nam quoniam eſt $VL \times CF = CV \times VE$; erit $VL : VE :: CV : CF :: VL : GF$ unde æquantur VE & GF. Si ad CG ex C excitetur normalis $CR = VE$ vel FG vel a, & per R agatur RS rectæ CV parallela, erit RS Curvæ Aſymptotos. Nam eſt recta MS æqualis arcui GF, & proinde FS diſtantia Curvæ ab RS eſt ſemper æqualis exceſſui quo arcus ſuperat ſuum ſinum: at cum diſtantia creſcat in infinitum, exceſſus ille minuetur in infinitum, & fiet tandem data quavis recta minor, & proinde RS erit Curvæ Aſymptotos.

Sit jam b major quam a; & ſimiliter, ut in priore caſu, invenietur $KN = \frac{a\dot{x}}{\sqrt{x^2 + b^2 - a^2}}$: at quoniam b ſuperat a, erit $c^2 = b^2 - a^2$ quantitas poſitiva, & KN fiet $= \frac{a\dot{x}}{\sqrt{x^2 + c^2}}$ & ponendo radium circuli $H\Upsilon = b$, invenietur $X\Upsilon = \frac{ba\dot{x}}{x\sqrt{x^2 + c^2}}$. Ponatur $x = \frac{c^2}{z}$, & erit $\dot{x} = -\frac{c^2\dot{z}}{z^2}$ & $\frac{\dot{x}}{x} = -\frac{\dot{z}}{z}$. Erit quoque $x^2 = \frac{c^4}{z^2}$ & $x^2 + c^2 = \frac{c^4}{z^2} + c^2$

$+ c^2 = \frac{c^4 + c^2 z^2}{z^2} = \frac{c^2}{z^2} \times \overline{c^2 + z^2}$: unde $\sqrt{x^2 + c^2} = \frac{c}{z} \times \sqrt{c^2 + z^2}$.

His itaque valoribus ſubſtitutis fit $\frac{ba\dot{x}}{x\sqrt{x^2 + c^2}} = -\frac{baz}{c\sqrt{c^2 + z^2}} = -\dot{y}$

Nam tale ſumi poteſt initium arcus HY, ut ſimul cum Fluente quantitatis $\frac{-ba\dot{z}}{c\sqrt{c^2 + z^2}}$ creſcat & decreſcat. Fiat $nc = a$ & erit $\frac{nb\dot{z}}{\sqrt{c^2 + z^2}}$ $= \dot{y}$, & $\frac{\frac{1}{2} nb^2 \dot{z}}{\sqrt{c^2 + z^2}} = \frac{1}{2} b\dot{y} =$ ſectori CXY.

Eſt autem $\frac{\frac{1}{2} nb^2 \dot{z}}{\sqrt{c^2 + z^2}} : \frac{\frac{1}{2} c^2 \dot{z}}{\sqrt{c^2 + z^2}} :: nb^2 : c^2$, hoc eſt in data ratione. Adeoque erit Sector CXY ad $\frac{\frac{1}{2} c^2 \dot{z}}{\sqrt{c^2 + z^2}}$ ſemper in data ratione. Harum itaque quantitatum Fluentes erunt in eadem ratione, cum ſimul incipere ponantur. Fluens autem Sectoris CXY eſt Sector CVY & Fluens quantitatis $\frac{\frac{1}{2} c^2 \dot{z}}{\sqrt{c^2 + z^2}}$ eſt Sector Hyperbolæ, quod ſic oſtenditur.

Fig. 158. Centro C ſemiaxe tranſverſo $CV = c$ deſcribatur Hyperbola æquilatera, & ex duobus punctis vicinis D & F ordinentur ad axem conjugatum rectæ DB, EF; ducantur item CD, CF. Et incrementum ſeu Fluxio Trianguli BCD æquale erit $BE \times BD$ — Sectore DCF: unde Sector DCF (qui eſt Fluxio Sectoris CVD) æqualis erit $BE \times BD$ — incremento Trianguli BCD. Et ſi BC dicatur z, ob Hyperbolam, eſt $BD^2 = BC^2 + CV^2 = z^2 + c^2$: unde $BD = \sqrt{c^2 + z^2}$, & $BE \times BD = \dot{z} \times \sqrt{c^2 + z^2}$. Triangulum autem BCD eſt $\frac{1}{2} z \times \sqrt{c^2 + z^2}$, cujus fluxio eſt $\frac{1}{2} \dot{z} \times \sqrt{c^2 + z^2} + \frac{\frac{1}{2} \dot{z} \times z^2}{\sqrt{c^2 + z^2}}$. Subtrahatur hæc quantitas ab $\dot{z} \times \sqrt{c^2 + z^2}$, & reſtabit Sector Hyperbolæ minimus CDF $= \frac{1}{2} \dot{z} \times \sqrt{c^2 + z^2} = \frac{\frac{1}{2} \dot{z} \times z^2}{\sqrt{c^2 + z^2}} = \frac{\frac{1}{2} \dot{z} \times \overline{c^2 + z^2} - \frac{1}{2} \dot{z} \times z^2}{\sqrt{c^2 + z^2}} =$ $\frac{\frac{1}{2} c^2 \dot{z}}{\sqrt{c^2 + z^2}}$. Adeoque Fluens Sectoris CDF eſt æqualis Fluenti quantitatis

tatis $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{c^2+z^2}}$. Proinde erit Sector CVD Fluens quantitatis $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{c^2+z^2}}$. Præterea $D\mathcal{T}$ recta tangat Hyperbolam & occurrat Axi conjugato in $\mathcal{T}$. Eſt ex natura Hyperbolæ $BC : CV :: CV : C\mathcal{T}$, hoc eſt $z : c :: c : \frac{c^2}{z} = C\mathcal{T} = z$. Atque hinc oritur conſtructio quæ ſequitur.

Centro C ſemiaxe tranſverſo CV, deſcribatur Hyperbola æquilatera Vm, item Circulus Ve. Capiatur Sector circularis CVe ad Sectorem hyperbolicum CVm ut n ad 1 ; tangat Hyperbolam in m recta $\mathcal{T}m$, occurrens Axi conjugato in $\mathcal{T}$: producatur Ce ad k ut ſit $Ck = C\mathcal{T}$, & punctum k erit in Curva quæſitâ. Nempe talis eſt ea Curva, ut ſi Ck dicatur x, perpendicularis à C in Tangentem ejus demiſſa erit ſemper æqualis $\frac{a\dot{x}}{\sqrt{b^2-x^2}}$. Quando x eſt infinita evaneſcit b^2, & perpendicularis fit $= a$, & tunc coincidit CR cum CV. Si itaque capiatur in axe conjugato $CR = a$, & ducatur RS ipſi CV parallela, erit hæc Curvæ Aſymptotos. Fig. 159

Si eo uſque augeatur a ut fiat quantitas $b^2 - a^2$ infinite parva, tunc evaneſcet c^2, & quantitas $\frac{ba\dot{x}}{x\sqrt{x^2+c^2}}$ fit $\frac{ba\dot{x}}{x^2} = \dot{y}$. Unde ſi capiantur harum quantitatum Fluentes, habebimus $\frac{ba}{x} = y$, & $ba = xy$, hoc eſt rectangulum ſub arcu circulari & diſtantia Curvæ à centro erit ſemper data quantitas ; atque hac ratione migrabit Curva in Spiralem hyperbolicam. Eſt itaque Spiralis hyperbolica Curva media, ſeu quaſi limes, inter eas Curvas, quæ conſtruuntur per Sectores circulares & eas quæ conſtruuntur per Sectores hyperbolicos. Itaque Spiralis illa hyperbolica concipi poteſt formari vel per Sectorem Circuli aut Ellipſeos, vel per Sectorem Hyperbolæ, cujus Axis tranſverſus minuitur in infinitum, & in eadem ratione augetur numerus n.

Ad eum jam devenimus caſum, ubi velocitas corporis minor eſt eâ quæ acquiritur cadendo ab infinita diſtantia, & ubi $p^2 = \frac{a^2x^2}{b^2-x^2}$. Et hic ſimili ratiocinio ac in priori caſu, invenietur $KN = \frac{a\dot{x}}{\sqrt{b^2-a^2-x^2}}$, ubi

neceſſe eſt ut ſit b^2 majus quam a^2. Hinc ſi $b^2 - a^2$ dicatur c^2, fit

$KN = \frac{a\dot{x}}{\sqrt{c^2 - x^2}}$; & proinde $X\Upsilon$ ſeu $\dot{y} = \frac{ba\dot{x}}{x\sqrt{c^2 - x^2}}$.

Sit jam $x = \frac{c^2}{z}$, & fiet $\frac{\dot{x}}{x} = -\frac{\dot{z}}{z}$ ſeu $\frac{ba\dot{x}}{x} = -\frac{ba\dot{z}}{z}$ & $c^2 - x^2$ erit $= \frac{c^2}{z^2} \times \overline{z^2 - c^2}$, quibus valoribus ſubſtitutis fit $\frac{-ba\dot{z}}{c\sqrt{z^2 - c^2}} = \frac{ba\dot{x}}{x\sqrt{x^2 - c^2}} = -\dot{y}$. Nam tale ponendum eſt initium arcus VX, ut ſimul cum Fluente quantitatis $\frac{ba\dot{z}}{c\sqrt{z^2 - c^2}}$ incipiat: unde erit

$\frac{\frac{1}{2}b^2 a\dot{z}}{c\sqrt{z^2 - c^2}} = \frac{1}{2}b\dot{y}$ = Sectori $CX\Upsilon =$, $\frac{\frac{1}{2}nb^2\dot{z}}{\sqrt{z^2 - c^2}}$, ponendo $nc = a$.

Eſt vero $\frac{\frac{1}{2}nb^2\dot{z}}{\sqrt{z^2 - c^2}}$ ad $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2 - c^2}}$ ut nb^2 ad c^2, hoc eſt in ratione conſtanti. Quare harum quantitatum Fluentes ſunt in eadem ratione, hoc eſt Fluens quantitatis $\frac{1}{2}b\dot{y}$ ſeu $\frac{\frac{1}{2}nb^2\dot{z}}{\sqrt{c^2 - z^2}}$ erit ad Fluentem quantitatis $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2 - c^2}}$ ut nb^2 ad c^2. Eſt autem Fluens quantitatis $\frac{1}{2}b\dot{y}$ = Sectori CVX, & Fluens quantitatis $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2 - c^2}}$ eſt Sector Hyperbolæ, quod ſic oſtenditur.

Fig. 160. Centro C ſemiaxe tranſverſo $CV = c$ deſcribatur Hyperbola æquilatera, & ex duobus punctis infinite vicinis B & D ad axem ordinentur duæ rectæ BE, DF; ducantur item GB, CD. Et erit Fluxio ſeu incrementum trianguli $CBE =$ triangulo $CBD + BE \times EF$; unde triangulum CBD, ſeu Sector minimus CBD, erit = incremento trianguli

anguli $CBE - BE \times EF$. Dicatur CEz, & erit $BE = \sqrt{z^2 - c^2}$, & $BE \times EF = \dot{z}\sqrt{z^2 - c^2}$. Eſt quoque triangulum $CBE = \frac{1}{2} z\sqrt{z^2 - c^2}$, cujus Fluxio eſt $\frac{1}{2}\dot{z} \times \sqrt{z^2 - c^2} + \frac{\frac{1}{2}\dot{z} \times z^2}{\sqrt{z^2 - c^2}}$; à quo ſi ſubtrahatur quantitas $\dot{z} \times \sqrt{z^2 - c^2}$, fit Sector minimus $CBD = \frac{\frac{1}{2}\dot{z} \times z^2}{\sqrt{z^2 - c^2}} - \frac{1}{2}\dot{z} \times \sqrt{z^2 - c^2} = \frac{\frac{1}{2}\dot{z} \times z^2 - \frac{1}{2}\dot{z} \times \overline{z^2 - c^2}}{\sqrt{z^2 - c^2}} = \frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2 - c^2}}$: unde conſtat Sectorem CBE eſſe Fluentem quantitatis $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2 - c^2}}$. Præterea ſi BT Tangens Hyperbolam Axi tranſverſo occurrat in T, ex natura Hyperbolæ fit $CE : CV :: CV : CT$, hoc eſt $z : c :: c : \frac{c^2}{z} = CT = x$.

Hinc deducimus ſequentem conſtructionem. Centro C, ſemiaxe tranſverſo $CV = c$, deſcribatur Hyperbola æquilatera VB, & circulus CeG ex centro C. Ad Hyperbolam ducatur recta CB, & Hyperbolæ Tangens BT Axi tranſverſo occurrat in T. Capiatur circuli Sector CVe, qui ſit ad Sectorem hyperbolicum CVB ut n ad 1. In Ce capiatur $CK = CT$, & erit K punctum in Curva quæſita, cujus perpendiculum è centro C ad Tangentem in K demiſſum, ſi CK dicatur x, eſt æquale $\frac{ax}{\sqrt{b^2 - x^2}}$. Fig. 161.

Et in hac Curva, urgente vi centripeta, quæ ſit reciprocè ut Cubus diſtantiæ, movebitur corpus, ſi ſecundum directionem Tangentis cum juſta velocitate exeat. Qualis autem debet eſſe velocitas, quæ faciat ut corpus harum Curvarum quamvis deſcribat, ſic invenietur.

Cum velocitas qua corpus in Trajectoria quacunque movetur ſit reciprocè ut quantitas p, aſſumendo conſtantem quamvis a, ea ſemper exponi poteſt per $\frac{a}{p}$. Et ſi ad Axem CV ordinentur rectæ, quæ ſint reciprocè ut cubi diſtantiarum à centro, ſeu ut vires centripetæ, & hac ratione formetur Figura curvilinea, ejus Area indefinitè extenſa ſemper exponi poteſt per $\frac{b^2}{x^2}$, ut ex Quadraturis conſtat. At Area illa eſt ut

quadratum velocitatis quæ acquiritur ab infinita diſtantia cadendo, adeoque velocitas hoc caſu acquiſita erit ut $\frac{b}{x}$. Hinc ſi velocitas illa dicatur y, & velocitas qua corpus in Trajectoria movetur dicatur v, taleſque aſſumantur quantitates a & b, ut in una aliqua à centro diſtantia ſit $y : v :: \frac{b}{x} : \frac{a}{p}$, erit ubique in omnibus diſtantiis $y : v :: \frac{b}{x} : \frac{a}{p} :: p : \frac{ax}{b}$. Unde ſi $y = v$, erit $p = \frac{ax}{b}$, & curva hac velocitate deſcripta erit Spiralis Nautica; vel Circulus exiſtente $p = x$ & $a = b$.

Si y ſit major quam v, tunc p major erit quam $\frac{ax}{b}$: eritque illa, ut ex præcedentibus conſtat, $= \frac{ax}{\sqrt{b^2 - x^2}}$, Curva autem conſtruetur per Sectorem hyperbolicum, ut in ultimo caſu oſtenſum fuit, ubi diſtantia corporis à centro per concurſum Tangentis Hyperbolæ cum Axe tranſverſo determinatur. Si y ſit minor quam v, at in tantilla ratione ut maneat b major quam a, Curva formabitur per eundem Sectorem hyperbolicum. At diſtantia corporis à centro deſumitur ex concurſu Tangentis cum Axe conjugato.

Si ſit $y : v :: p : x$, erit in eo caſu $a = b$, & Curva evadit Spiralis hyperbolica, ubi eſt $p = \frac{ax}{\sqrt{a^2 - x^2}}$. Hinc ſi de loco quovis projiciatur corpus ſecundum datam rectam, cum ea velocitate, quæ ſit ad velocitatem ab infinito cadendo acquiſitam, ut diſtantia corporis à centro ad perpendicularem è centro ad lineam directionis demiſſam, movebitur illud corpus in Spirali hyperbolica. Si denique ſit v tantò major quam y, ut ſit etiam a major quam b, Curva conſtruetur per Sectores circulares. Atque hac ratione datâ velocitate ſemper determinari poſſit relatio quantitatum a & b, ac proinde Curva deſcribetur in qua corpus cum illa velocitate movebitur: & viciſſim data Curva, ſeu datis quantitatibus a & b, invenietur velocitas qua Curva illa deſcribitur.

Omnium Curvarum Areæ (ſi circulum excipias) quæ urgente hac vi centripetâ deſcribi poſſunt, ſunt perfectè quadrabiles. Nam primo, in

Spirali logarithmica, quia eſt $p = \frac{ax}{b}$, erit $KN = \frac{a\dot{x}}{\sqrt{b^2 - a^2}} = \frac{a\dot{x}}{c}$,

ponendo $b^2 - a^2 = c^2$: *vid. Fig.* 155. adeoque erit Triangulum $CKI =$ Fig. 155.

$\frac{\frac{1}{2}ax\dot{x}}{c}$, cujus Fluens eſt $\frac{ax^2}{4c}$ = Areæ Curvæ.

Si p ſit $\frac{ax}{\sqrt{b^2 + x^2}}$, & a major quam b, oſtenſum eſt $KN = \frac{a\dot{x}}{\sqrt{x^2 - c^2}}$,

unde $KN \times \frac{1}{2}CI = \frac{\frac{1}{2}ax\dot{x}}{\sqrt{x^2 + c^2}}$, cujus Fluens eſt $\frac{1}{2}a \times \sqrt{x^2 - c^2} =$ Areæ Curvæ. At ſi a minor ſit quam b, ſit $KN = \frac{a\dot{x}}{\sqrt{x^2 + c^2}}$, & $KN \times \frac{1}{2}$

$CI = \frac{\frac{1}{2}ax\dot{x}}{\sqrt{x^2 + c^2}}$, cujus Fluens eſt $\frac{1}{2}a\sqrt{x^2 + c^2} - \mathcal{Q} =$ Areæ Curvæ.

Ponatur $x = 0$, & fiet $\frac{1}{2}ac - \mathcal{Q} = 0$, unde $\mathcal{Q} = \frac{1}{2}ac$, & Area Curvæ fit $= \frac{1}{2}a\sqrt{x^2 + c^2} - \frac{1}{2}ac$.

In Spirali hyperbolica evaneſcit quantitas c, & Area Curvæ fit $\frac{1}{2}ax$.

Si p ſit $= \frac{ax}{\sqrt{b^2 - x^2}}$, oſtenſum eſt eſſe $KN = \frac{a\dot{x}}{\sqrt{c^2 - x^2}}$, unde $\frac{1}{2}CI \times KN = \frac{\frac{1}{2}ax \times x\dot{x}}{\sqrt{c^2 - x^2}}$, cujus Fluens eſt $\mathcal{Q} - \frac{1}{2}a\sqrt{c^2 - x^2} =$ Areæ. Fiat

$x = 0$, & erit $\mathcal{Q} - \frac{1}{2}ac = 0$, ſeu $\mathcal{Q} = \frac{1}{2}ac$; unde erit Area Curvæ ſemper æqualis $\frac{1}{2}ac - \frac{1}{2}a\sqrt{c^2 - x^2}$. Fiat $c^2 - x^2 = 0$ ſeu $c = x$, & Area Curvæ fit $\frac{1}{2}ac$. Unde ſi initium Areæ non capiatur ab initio ipſius x, ſeu ubi x eſt $= 0$, ſed ubi $x = c$ eſt maxima, hoc eſt ſi Area ab V incipiat, (*vid. Fig.* 160.) erit Area ſemper æqualis $\frac{1}{2}a\sqrt{c^2 - x^2}$. Fig. 160.

De Areis quas deſcribunt corpora radiis ad centrum ductis, urgente vi centripeta quæ ſit reciprocè ut diſtantiarum cubi, ſequentia adnotavit peritiſſimus *Halleius*. Nempe ſi corpora diverſos circulos vel diverſas Spirales hyperbolicas hac lege deſcribunt; erunt Areæ Sectorum,

tam

tam in Circulis quam in Spiralibus illis omnibus, æqualibus temporibus deſcriptæ, ſemper æquales: Nam velocitates corporum in circulis motorum ſecundum hanc legem, debent eſſe radiis ſeu diſtantiis reciprocè proportionales, adeoque arcus ſimul percurſi erunt quoque in eâdem radiorum reciprocâ ratione, unde ſtatim patebit Sectores ſimul deſcriptos eſſe æquales.

In reliquis omnibus Curvis cum ſit velocitas ad velocitatem corporis in eadem diſtantia in circulo moti ut $\frac{a}{b} \times x$ ad p, (*vide Fig.* 156.) ſeu ut $\frac{a}{x} \times IK$ ad KN; interea dum corpus in Trajectoria percurrit Lineolam IK, corpus aliud in eadem diſtantia motum percurret arcum $\frac{b}{a} \times KN$; & Area Sectoris Circuli & Trajectoriæ ſimul deſcriptæ erunt $\frac{b}{a} \times KN \times \frac{1}{2} CN$, & $KN \times \frac{1}{2} CN$, quæ duæ Areæ ſunt in ratione data, ſcil. ut b ad a. Adeoque ubi eſt $a = b$, uti fit in Spirali hyperbolica, Area ſic deſcripta erit ſemper æqualis Areæ Sectoris circularis in æquali tempore deſcriptæ.

Fig. 156.

To find the Center *of* Oſcillation, *by Dr.* B. Taylor. n. 337. p. 11.

VII. Definitio.] *Eſt Centrum Oſcillationis punctum quoddam in corpore pendulo, cujus vibrationes ſingulæ eodem modo atque eodem tempore peraguntur, ac ſi illud ſolum ad eandem diſtantiam a puncto ſuſpenſionis filo ſuſpenderetur.*

Per ſe vix ſatis manifeſtum eſt in corpore aliquo dari hujuſmodi punctum: utpote cujus acceleratio debeat, (*per hanc def.*) in omnibus inclinationibus corporis penduli ad Horizontem, perinde eſſe, ac ſi a propriâ tantum gravitate urgeatur; reliquis particulis totius corporis ejus motum proprium haud perturbantibus. Itaque in ordine ad inventionem hujus Centri, præmittenda eſt una atque altera propoſitio, unde conſtet tale punctum dari.

Prop. 1. Prob. 1.] *In Corporis oſcillantis datâ quâvis inclinatione ad Horizontem invenire punctum, cujus acceleratio perinde ſit, ac ſi ab ipſius propriâ tantum gravitate urgeatur.*

Fig. 162.

Sit A B D corporis propoſiti Sectio in plano ad Horizontem perpendiculari, in quo movetur centrum gravitatis G, centro ſuſpenſionis exiſtente C. Diſtinguatur corpus in elementa priſmatica plano A B D perpendicularia, adeoque Horizonti ſemper parallela; ut facile patebit ex motu centri gravitatis G in plano illo A B D. Atque ob hujuſmodi ſitum, tale elementum quodvis ſpectari poteſt tanquam punctum Phyſicum p in plano eodem A B D ad punctum z locatum. Reducatur

tur itaque corpus propoſitum in planum Phyſicum ABD conſtans ex hujuſmodi particulis p.

In hoc plano ut inveniatur punctum O, cujus acceleratio propria non mutatur ab actionibus particularum reliquarum, attendendum eſt ad vires particulæ cujuſvis ſingularis p in puncto z ſitæ. Nam ex hiſce viribus conjunctis oritur plani totius motus abſolutus; cujus ope datur motus puncti cujuſvis propoſiti; unde viciſſim invenitur punctum cujus motus eſt datus.

At urgetur particula p a vi propriæ gravitatis; quæ ſi partium cohæſio diſſolveretur, in dato tempore minimo, datam produceret acceleration̄em motus in perpendiculari ad Horizonentem zy. Ad Cz duc normalem yx, & reſolvetur acceleratio zy in partes zx & xy. Ob corporis rigiditatem, tollitur vis zx per reſiſtentiam puncti C. At vi reliquâ xy trahitur ſpatium ABD in gyrum circa punctum C; & ductâ horizontali Co & perpendiculari zs, erit ea ut $\frac{Cs}{Cz}$: Nempe ob gravitatis vim datam, & ſimilia triangula xyz & sCz. Ergo vis particulæ p ad movendum ſpatium ABD eſt ut $\frac{Cs}{Cz} \times p$.

Ad has vires in unum colligendas, ſit O punctum invariabile, in lineâ ad libitum ducta & ad diſtantiam adhuc incognitam CO. Tum erit vis particulæ p ad movendum punctum O, ut $\frac{Cz}{CO} \times \frac{Cs}{Cz} \times p$, hoc eſt ut $\frac{Cs}{CO} \times p$. Acceleratio autem, quam tribuit p eidem puncto O, erit ut $\frac{CO}{Cz} \times \frac{Cs}{Cz}$. Itaque applicatâ vi illâ $\frac{Cs}{CO} \times p$ ad hanc acceleration̄em $\frac{CO \times Cs}{Czq}$, erit quotiens $\frac{Czq:}{COq:} \times p$ particula, quæ, ſi in ipſo puncto O fingatur moveri cum eâdem acceleratione $\frac{CO \times Cs}{Czq}$, eundem omnino produceret motum, quem in eodem puncto O producit particula p. Hinc demum reducitur Problema ad motuum Theorema notiſſimum: Applicatâ enim ſummâ virium $\frac{Cs}{CO} \times p$ ad ſummam particularum $\frac{Czq:}{COq:} \times p$, erit quotiens acceleratio abſoluta puncti O.

Dein ductâ perpendiculari O*o*, & poſitâ hac acceleratione æquali datæ accelerationi $\frac{C\,o}{CO}$ ipſius puncti O, dabitur diſtantia CO. Sit enim $\frac{C\,o}{CO} = d$, & (juxta methodum *Fluxionum*) $C\,s \times p = \dot{M}$, & $C\,z\,q : \times p = \dot{C}$. Tum ob CO invariabilem erit ſumma omnium virium $\frac{C\,s}{CO} \times p = \frac{M}{CO}$, & ſumma omnium particularum $\frac{C\,z\,q:}{CO\,q:} \times p = \frac{C}{CO\,q}$. Unde, applicatâ ſummâ momentorum ad ſummam corporum, erit $\frac{M}{C} \times CO = d$ adeoque $CO = \frac{d\,C}{M}$. Inventis igitur C & M, per *Fluxionum* methodum inverſam, dabitur CO. Q. E. I.

Cor. A centro gravitatis G ad horizontalem C*o* duc perpendicularem G*g*, & ſit corpus ipſum A B C = A. Tum ex notiſſimâ indole centri gravitatis erit $M = C\,g \times A$. Unde eſt $CO = \frac{d\,C}{C\,g \times A}$.

Prop. 2. Theor. 1.] *Iiſdem poſitis, quæratur punctum O in rectâ C G tranſeunte per centrum gravitatis G, Tum erit O centrum Oſcillationis corporis A.*

Fig. 163. Etenim in hoc caſu fit $\frac{C\,o}{CO} = \frac{C\,g}{CG} = d$; Unde $CO = \left(\frac{d\,C}{C\,g \times A}\right.$, *per. Cor. Prop.* 1.$\left.\right) \frac{C}{CG \times A}$. At datur A, & dato puncto C, dantur CG & quantitas C. Unde datur CO, qualiſcunque ſit corporis Oſcillantis inclinatio ad Horizontem. Ideoque *per Def. & Prob.* 1. eſt O centrum Oſcillationis corporis A. Q. E. D.

Prop. 3. Theor. 2.] *Iiſdem poſitis, ſit D aggregatum omnium* $G\,z^2 \times p$ *Tum erit* $CO = CG + \frac{D}{CG \times A}$.

Fig. 164. Ad CG duc normalem z F, atque erit $C\,z\,q: = CG\,q: + G\,z\,q: - 2\,CG \times GF$, nempe cadente F intra C & G. At ubi F cadit in CG productâ, erit $C\,z\,q: = CG\,q: + G\,z\,q: + 2\,CG \times G\,f$. Eſt ergo C = (aggregato omnium $C\,z\,q: \times p =$) aggregato omnium $CG\,q: \times p + G\,z\,q: \times p - 2\,CG \times GF \times p + 2\,CG \times G\,f$

$Gf \times p$. At ob centrum gravitatis G, eſt aggregatum omnium 2 CG $\times$ GF $\times p$ = aggregato omnium 2 CG $\times$ $Gf \times p$. Quare eſt C = aggregato omnium $CGq : \times p + Gzq : \times p = CGq : \times \overline{A+D}$. At enim *per Theor.* 1. eſt $CO = \frac{C}{CG \times A}$. Ergo $CO = CG + \frac{D}{CG \times A}$. Q. E. D.

Cor. Hinc datur Parallelogrammum CG $\times$ GO. Eſt enim $GO = \frac{D}{CG \times A}$. At dantur A & D. Quare datur $CG \times GO = \frac{D}{A}$.

Prop. 4. Theor. 3.] *Iiſdem poſitis, ſi in puncto O conſtituatur particula phyſica* $\frac{CG \times A}{CO}$, *quæ propria gravitate agitata oſcillet circa punctum C; ſpatii ABC motus perinde omnino erit, ac ſi agitaretur ab Oſcillatione ipſius corporis A.*

Conſtat tam ex Natura centri gravitatis, quam *per Prob.* 1. Eſt enim $\frac{CG \times A}{CO}$ aggregatum omnium $\frac{Czq : \times p}{COq} = \frac{C}{COq :}$.

Prop. 5. Prob. 2.] *Datis corporis cujuſvis magnitudine A, centro gravitatis G, & puncto ſuſpenſionis C. Invenire ejuſdem centrum Oſcillationis O.*

Fit per Theor. 1. inveniendo quantitatem C; vel per Theor. 2. quærendo quantitatem D.

Scholium.] Ad inſtituendum calculum in caſu particulari, eligenda eſt quantitas C vel D, prout ſuggerit natura figuræ propoſitæ. Dein datâ earum alterutrâ, altera item dabitur per Æquationem (*Prop.* 3.) $C = CGq : \times \overline{A+D}$. Unde etiam dabitur *pgr.* $CG \times GO \doteq \frac{D}{A}$ (*Cor. Prop.* 3.) $= \frac{C}{A} - CGq :$. Cujus ope, ex datis centro gravitatis & puncto ſuſpenſionis, datur centrum Oſcillationis per ſolam diviſionem. Quare in quolibet exemplo ſemper commodiſſimum erit hoc parallelogrammum primum eruere, vel per computum ipſius D, vel per quantitatem C, ex idoneâ aſſumptione centri ſuſpenſionis.

Supereſt, ut hæc exemplis aliquot illuſtremus.

Ex. 1. Sit figura propoſita Pyramis ADC, cujus Baſis eſt *pgr.* AD, ſitque motus centri gravitatis in plano tranſeunte per verticem C & diametrum Baſis EF lateri AB parallelam. Fig. 165.

Ad calculum commodiſſime inſtituendum, ſit ipſe vertex C centrum ſuſpenſionis. Tum ad modum *Prob.* 1. reducatur figura ad planum phyſicum Trianguli Iſoſcelis CEF, in quo *ef* parallela ipſi EF repræſentat lineam phyſicam ex particulis *p* compoſitam. Sit $CH = a$, $HF = b$, & $Ch = x$. Fig. 166.

Tum ex naturâ figuræ erit $eh = \frac{bx}{a}$, & particula p ſita ad punctum z erit ut x; vel potius, facto $hz = v$ erit $\dot{v}\dot{x}$ elementi priſmatici Baſis, & p erit ut $\dot{v}\dot{x}x$. Unde erit $\dot{C} = Czq : x\dot{v}\dot{x}x = \dot{v}\dot{x}x^3 + \dot{x}\dot{v}v^2x$. Ideoque ſumma omnium $Czq : xp$ in lineâ hz erit $v\dot{x}x^3 + \frac{\dot{x}xv^3}{3}$; & in lineâ ef (pro v ponendo $\frac{bx}{a}$) erit ſumma illa $\frac{6ba^2 + 2b^3}{3a^3} \times xxx^4$

Unde iterum capiendo Fluentem, & pro x ſcribendo a, erit $C = \frac{6ba^2 + 2b^3}{15} \times a^2$. Eſt autem pyramis ipſa $A = \frac{2baa}{3}$, & diſtantia centri gravitatis G a vertice C eſt $CG = \frac{3}{4}a$. Unde $\frac{C}{A} - CGq : = \frac{D}{A} = CG \times GO = \frac{3a^2 + 16b^2}{80}$.

Ex. 2. Sit figura propoſita Conus rectus deſcriptus rotatione trianguli Iſoſcelis ECF circa perpendiculum CH.

Hic iterum ſumpto vertice C pro centro ſuſpenſionis, & factis $CH = a$, $HE = b$, $Ch = x$, $hz = v$, ut ſupra; erit $p = 2\dot{x}\dot{v}\sqrt{\frac{bb}{aa}xx - vv}$; unde $\dot{C} = 2\dot{v}\dot{x} \times xx + vv \times \sqrt{\frac{bb}{aa}xx - vv}$. Sit B ſegmentum circuli diametro ef deſcripti, quod adjacet Abſciſſæ $hz = v$, & Ordinatæ $\sqrt{\frac{bb}{aa}xx - vv}$; tum erit ſumma omnium $Czq : xp$ in rectâ $hz = 2\dot{x} \times \frac{4a^2 + b^2}{4a^2}x^2\,B - \frac{1}{2}\dot{x}v \times \left|\frac{b^2}{a^2}x^2 - v^2\right|^{\frac{1}{2}}$. Et quando $v = eh$, erit hæc ſumma $2\dot{x} \times \frac{4a^2 + b^2}{4a^2}x^2B$; cujus duplum $\frac{4a^2 + b^2}{a^2}\dot{x}x^2\,B$ eſt pars ipſius C in ef. Eſt autem Area B ut x^2; ſit ergo

$B = c\,x^2$; atque pars illa ipſius C erit $\frac{4a^2+b^2}{a^2} \times c\,\dot{x}\,x^4$. Unde capiendo Fluentem erit $C = \frac{4a^2+b^2}{5} \times c\,a^3$. Eſt autem Conus ipſe $A = \frac{4}{3}\,c\,a^3$, & $CG = \frac{1}{4}\,a$. Unde $\frac{C}{A} - CG\,q: = \frac{D}{A} = \frac{3a^2+12b^2}{80}$

Atque ad hunc modum procedit calculus in aliis figuris, ubi rationes Cb ad be, & bz ad p ſunt magis compoſitæ.

Ex. 3. Ut pateat ratio calculi quantitatis D, ſit figura propoſita Parallelepipedon, cujus facies Horizonti perpendicularis, & parallela plano motûs centri gravitatis eſt ABD. Duc diametros EF & HI, & ſit altitudo elementorum p, :: & ſit tr parallela HI; & $GF = a$, $GH = b$, $Gs = x$, & $sz = v$. Tum erit $\dot{D} = \dot{v}\,\dot{x}\,x\,x + \dot{x}\,\dot{v}\,v\,v$. Unde ipſius D pars in rectâ tr erit $2b\,\dot{x}\,x^2 + 2b^3\,\dot{x}$: atque iterum ſumendo Fluentis duplum, erit $D = \frac{4b\,a^3+b^3\,a}{3}$. Atqui eſt $A = 4ab$; unde eſt $\frac{D}{A} = \frac{aa+bb}{3} = \frac{1}{12}$ DB quad. Fig. 167.

Ex. 4. Sit ultimum exemplum in Sphærâ, cujus circulus maximus Btr, diameter AB, & centrum G. Tum ductis lineis, ut in Schemate ſatis patent, erit $\dot{D} = Gsq: \times p + Gmq \times p$. At ſumma omnium $Gsq: \times p$ in recta tr eſt $Gsq:$ ductum in Aream circuli diametro tr deſcripti. Item ſumma omnium $GMq: \times p$ in rectâ ki eſt $Gmq: \times$ Aream circuli diametro ki deſcripti. Unde ſtatim conſtat eſſe D = quater Fluenti ipſius $Gsq:$ in Aream circuli cujus diameter eſt tr. Sit ergo c Area circuli cujus radii quadratum eſt 1, & ſit $GA = a$, & $Gs = x$. Tum erit $\dot{D} = 4\,\dot{x}\,x\,x\,x\,caa - c\,x\,x = 4\,c\,a^2\,\dot{x}\,x^2 - 4\,c\,\dot{x}\,x^4$. Unde ſumendo Fluentem & faciendo $x = a$, erit $D = \frac{8}{15}\,c\,a^5$. Eſt autem $A = \frac{4}{3}\,c\,a^3$. Unde $\frac{D}{A} = \frac{2}{5}\,a\,a$. Fig. 168.

Ob

Ob affinitatem ſolutionis libet his ſubjungere Problema de inventione Centri Percuſſionis.

Prop. 6. Prob. 3.] *Corporis cujuſvis circa datum punctum rotati, invenire Centrum Percuſſionis; punctum ſcilicet tale, ut Corpus in illud impingens, & eâdem operâ ſolutum a puncto ſuſpenſionis, neque huc neque illud inclinet.*

Primùm conſtat hoc punctum quæri debere in plano motus centri gravitatis. Si enim corpus reſolvatur in elementa priſmatica plano iſti normalia, ferentur ea motu ſibi parallelo; unde momenta ex utrâq; parte iſtius plani erunt æqualia; adeoque per reſiſtentiam factam in hoc plano, corporis punctum nullum de eo pelletur. Sit ergo planum illud Fig. 169. AB, ad quod reducetur corpus per contractionem elementorum priſmaticorum in particulas p ad puncta z ſitas, ut in *Prob.* 1. In hoc plano ſit C centrum rotationis; aut ſaltem ejus projectio facta per lineam perpendicularem in hoc planum demiſſam; & ſit Q punctum quæſitum. Per C duc ad libitum C ξ in qua ſume puncta duo z & ξ, ita ut ductis zQ & ξQ, ſit angulus C z Q obtuſus, & angulus C ξ Q acutus: atque in punctis z & ξ ſint particulæ p & π. Tum ad C ξ ductis normalibus zr & ξr, quæ ſint ad invicem ut C z ad C ξ, iis repræſentabuntur velocitates abſolutæ particularum p & π. At harum velocitatum partes, quæ ſunt in directionibus zQ & ξQ, tolluntur per reſiſtentiam puncti Q. Ad Qz & $Q\xi$ duc normales CD & C d, & ob angulos æquales $zCD = rzQ$, & $\xi Cd = r\xi Q$, velocitatum partes reliquæ, in directionibus ipſis Qz & $Q\xi$ perpendicularibus, erunt ut zD & ξd. Unde habitâ ratione diſtantiarum Qz & $Q\xi$ erunt vires particularum p & π ad movendum ſpatium AB in partes contrarias, ut $Dz \times zQ \times p$, & $d\xi \times \xi Q \times p$. At per conditiones Problematis debent ſummæ hujuſmodi contrariarum virium eſſe inter ſe æquales.

Ob angulos ad D & d rectos, ſunt puncta D & d ad circumferentiam circuli diametro CQ deſcripti. Sit iſtius circuli centrum E. Tum ductis E z & E ξ circulo occurrentibus in F & I, f & i, erit $Dz \times zQ = Fz \times zI = EFq: - Ezq: = EQq: Ezq:$ & $d\xi \times \xi Q = E\xi q: - EQq:$ Quare erit ſumma omnium $EQq: \times p - Ezq: \times p =$ ſummæ omnium $E\xi q: \times \pi - EQq \times \pi$; & terminis tranſpoſitis, ſumma omnium $EQq: \times p + \pi: =$ ſummæ omnium $Ezq: \times p + E\xi q: \times \pi$, hoc eſt, ſi p ponatur tam pro particulâ p intra circulum, quam pro particula π extra circulum, erit ſumma omnium $EQq: \times p =$ ſummæ omnium $Ezq: p$. Ad CQ duc normalem zs. Tum erit $Ezq: = Czq: + ECq - QC \times Cs$. Quo valore ipſius $Ezq:$ ei ſubſtituto, & Æquatione debitè tractatâ, tandem invenies ſummam omnium $CQ \times Cs \times p =$ ſummæ omnium $Czq: \times p$. Unde eſt CQ

$$= \frac{\text{ſummæ omnium } Czq: \times p}{\text{ſumm: omnium } Cs \times p}.$$

At enim eſt ſumma omnium $Czq: \times p$

Fig. 152.

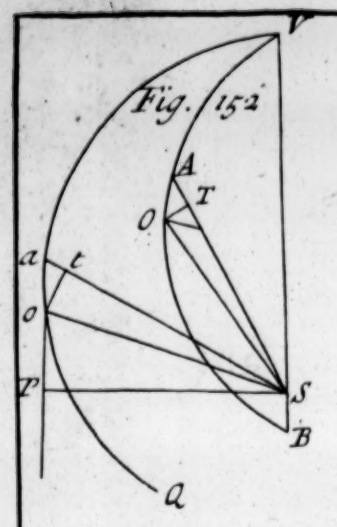


Fig. 153.

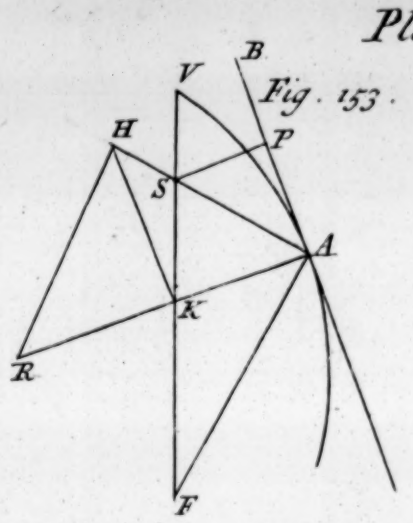


Fig. 154.

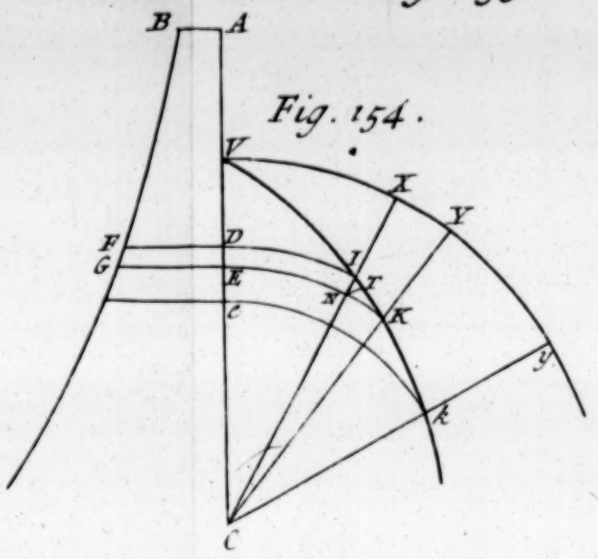


Fig. 155.

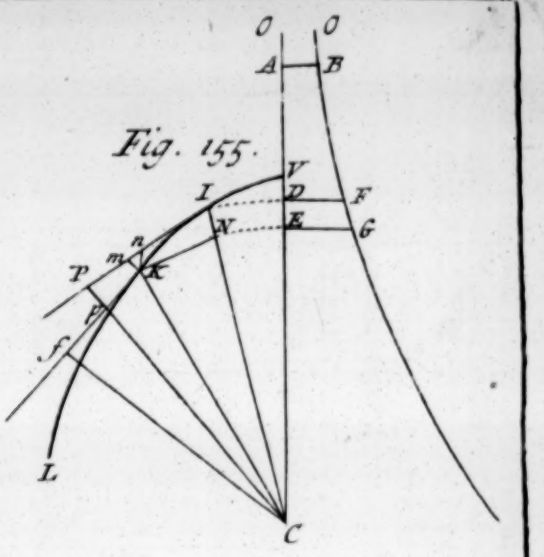


Fig. 156.

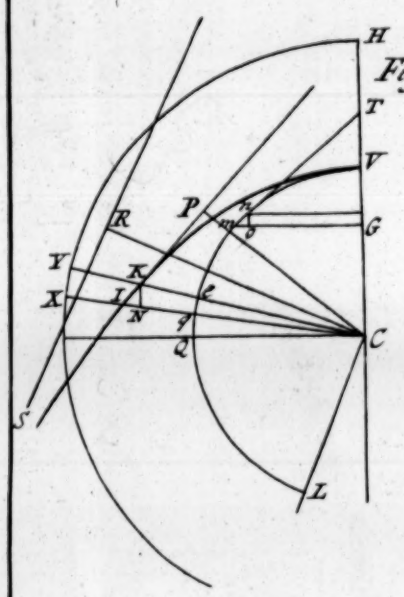
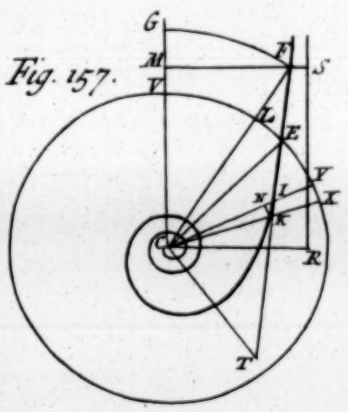
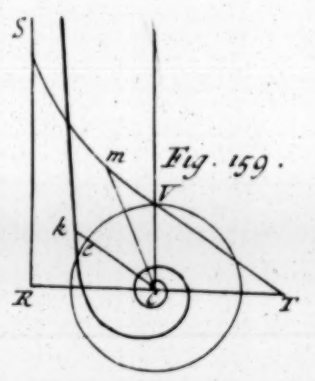


Fig. 157.





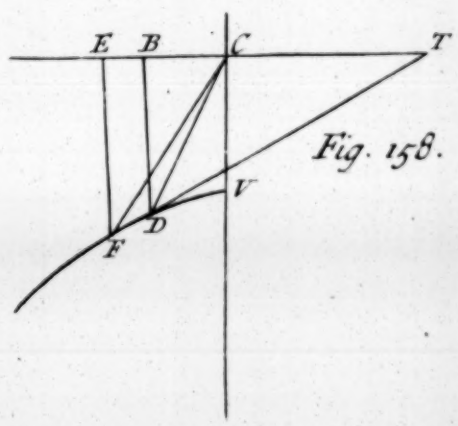


Fig. 165.

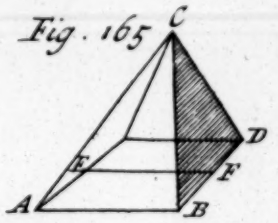


Fig. 162.

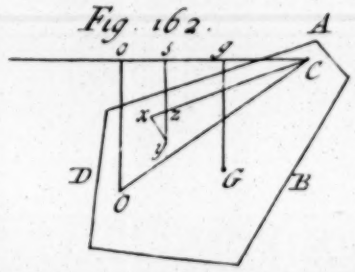


Fig. 160.

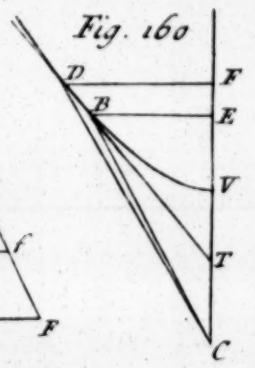


Fig. 161.

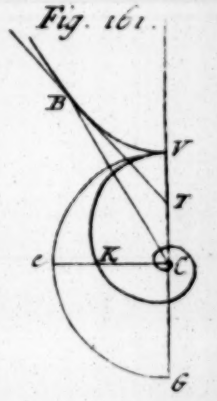


Fig. 169.

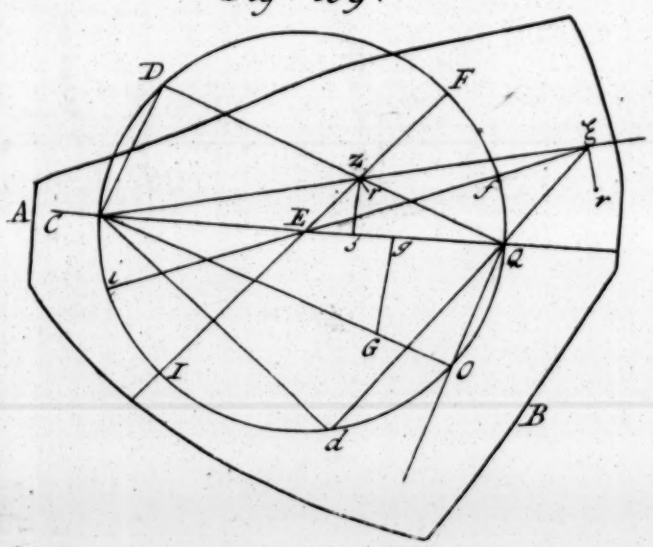


Fig. 166.

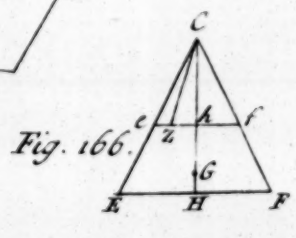


Fig. 168.

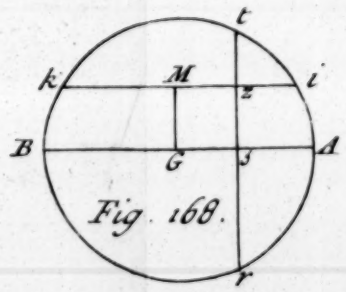


Fig. 167.

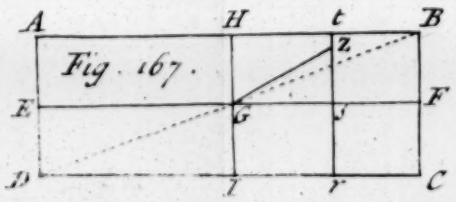


Fig. 163.

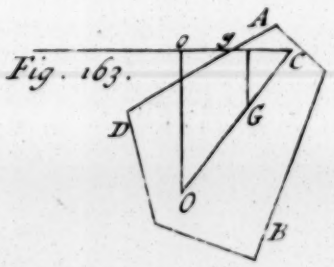
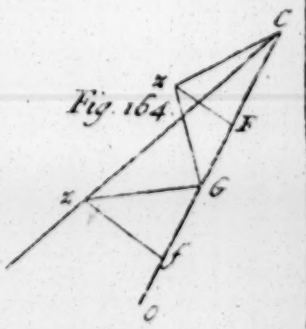


Fig. 164.



ipſa quantitas C in calculo centri Oſcillationis: & ſi centrum gravitatis ſit G, & ad CQ ducatur normalis Gg, & corpus ipſum dicatur A, erit ſumma omnium $Cs \times p = Gg \times A$. Unde eſt CQ $= \frac{C}{Cg \times A}$. Set centrum Oſcillationis O; tum per *Theor.* 1. erit $CO = \frac{C}{CG \times A}$. Unde eſt $Cg : CG :: CO : CQ$. Quare per O ducta ad CO perpendicularis tranſibit per punctum Q. Q.E.I.

VIII. Lemma 1.] *Sint* A D F B, *&* A Δ Φ B *Curvæ duæ, quarum relatio inter ſe hæc eſt, ut, ductis ad libitum Ordinatis* C Δ D, E Φ F, *ſit* C Δ : C D :: E Φ : E F. *Tum Ordinatis in infinitum imminutis, adeo ut coincidant Curvæ axe* A B; *dico quod ſit ultima ratio Curvaturæ in* Δ *ad Curvaturam in* D, *ut* C Δ *ad* C D.

Of the Motion *of a* ſtretcht String, *by Dr.* B. Taylor. n. 337. p. 26. Fig. 170.

Demonſtr. Duc Ordinatam $c\delta d$ ipſi C D proximam; & ad D & Δ duc Tangentes D *t* & Δ θ Ordinatæ *c d* occurrentes in *t* & θ. Tum ob $c\delta : cd :: C\Delta :: CD$ (per Hypotheſin) Tangentes productæ ſibi invicem & axi occurrent in eodem puncto *P*. Unde ob Triangula ſimilia C D P & *c t* P, C Δ P & *c* θ P, erit $c\theta : ct :: C\Delta : CD$ ($:: c\delta : cd$, per Hyp.) $:: \delta\theta$ ($= c\theta - c\delta$) ad dt ($= ct - cd$.) Atqui ſunt Curvaturæ in Δ & D, ut anguli contactus θ Δ δ & *t* D *d*; & ob δ Δ & *d* D coincidentes cum *c* C, anguli iſti ſunt ut eorum ſubtenſæ δ θ & dt, hoc eſt (per analogiam ſupra inventam) ut C Δ & C D. Quare, *&c.* Q.E.D.

Lemma 2.] *In aliquo articulo vibrationis ſuæ induat Nervus tenſus, inter puncta* A *&* B, *formam Curvæ cujuſvis* A *p* π B. *Tum dico quod ſit incrementum velocitatis puncti alicujus* P, *ſeu acceleratio oriunda a vi tenſionis Nervi, ut Curvatura Nervi in eodem puncto.* Fig. 171.

Demonſtr. Finge Nervum conſtare ex particulis rigidis æqualibus infinite parvis *p* P & P π, *&c.* & ad punctum P erige perpendicularem P R = Radio Curvaturæ in P, cui occurrant Tangentes *p t* & π *t* in *t*, iis parallelæ π *s* & *p s* in *s*, chorda *p* π in *c*. Tum, per Principia Mechanicæ, vis abſoluta, quâ urgentur particulæ ambæ *p* P & P π verſus R, erit ad vim tenſionis fili, ut *s t* ad *p t*; & hujus vis dimidium, quo urgetur particula una *p* P, erit ad Nervi tenſionem, ut *c t* ad *t p*, hoc eſt, (ob triangula ſimilia *c t p*, *t p* R) ut *t p* vel *P p* ad R *t* vel P R. Quare, ob tenſionis vim datam, erit vis acceleratrix abſoluta ut $\frac{Pp}{PR}$. Sed eſt acceleratio genita in ratione compoſitâ ex rationibus vis abſolutæ directè & materiæ movendæ inverſe; atque eſt materia movenda ipſa particula P *p*. Quare eſt acceleratio ut $\frac{1}{PR}$, hoc eſt ut Curvatura in P. Eſt enim Curvatura reciprocè ut Radius circuli oſculatorii. Q.E.D.

Prob. 1.

Prob. 1. *Definire motum nervi tenſi.*

In hoc Problemate & ſequentibus pono Nervum moveri per ſpatium minimum ab Axe motûs; ut incrementum tenſionis ex auctâ Longitudine, item obliquitas radiorum Curvaturæ poſſint tutò negligi.

Fig. 172. Itaque extendatur Nervus inter puncta A & B; & plectro deducatur punctum *z* ad diſtantiam C*z* ab Axe AB. Tum amoto plectro, ob flexuram in puncto ſolo C, illud primum incipiet moveri (*per Lemma* 2.) At ſtatim inflexo Nervo in punctis proximis Φ & *d*, incipient hæc puncta etiam moveri; & deinde *E* & *e*, & ſic deinceps. Item ob magnam flexuram in *C*, illud punctum primò velociſſimè movebitur; & exinde auctâ Curvaturâ in punctis proximis *D*, *E*, *&c.* ea continuo velocius accelerabuntur; & eâdem operâ, imminutâ Curvaturâ in C, id punctum viciſſim tardius accelerabitur. Et univerſaliter, punctis juſtò tardioribus magis & velocioribus minùs acceleratis, tandem fiet ut viribus inter ſe ritè temperatis, motus omnes conſpirent, punctis omnibus ad Axem ſimul euntibus & ſimul redeuntibus, vicibus alternis ad infinitum.

Sed ut hoc fiat, debet Nervus ſemper induere formam Curvæ ACD EB, cujus Curvatura in quovis puncto E eſt ut ejuſdem diſtantia ab Axe Eη; velocitatibus etiam punctorum C, D, E, *&c.* conſtitutis inter ſe in ratione diſtantiarum ab Axe C*z*, Dϑ, Eη, *&c.* Etenim in hoc caſu, ſpatia C*x*, Dδ, Eε, *&c.* eodem tempore minimo percurſa, erunt inter ſe ut velocitates, hoc eſt ut ſpatia percurrenda D*z*, Dϑ, *&c.* Unde erunt ſpatia reſidua *xz*, $\delta\vartheta$, $\varepsilon\eta$, *&c.* inter ſe in eadem ratione. Item (*per Lemma* 2.) erunt accelerationes inter ſe in eadem ratione. Quo pacto, ſemper ſervata ratione velocitatum inter ſe eâdem ac ſpatiorum percurrendorum, puncta omnia ſimul pervenient ad Axem & ſimul redibunt: adeoque recte definitur Curva ACDEB. Q. E. D.

Præterea, comparatis inter ſe duabus Curvis ACDEB, & A*x*$\delta\varepsilon$B, *per Lemma* 1. erunt Curvaturæ in D & δ, ut diſtantiæ Axe Dϑ & $\delta\vartheta$: adeoque *per Lemma* 2. acceleratio dati cujuſvis puncti in Nervo erit ut ejuſdem diſtantia ab Axe. Unde (*per Phil. Nat. Princip. Math. Sect.* X. *Prop.* 51.) vibrationes omnes, tam maximæ quam minimæ, peragentur in eodem tempore periodico, & puncti cujuſvis motus ſimilis erit oſcillationi corporis Funipenduli in Cycloide. Q. E. I.

Cor. Sunt Curvaturæ reciprocè ut radii circulorum oſculantium. Sit ergo *a* linea data, atque erit radius Curvaturæ in E $= \frac{a\,a}{E\eta}$.

Prob. 2. *Datis Longitudine & pondere Nervi, unà cum pondere tendente; invenire tempus unius vibrationis.*

Fig. 173. Extendatur nervus inter puncta A & B per vim ponderis P, & ſit nervi ipſius pondus N, & Longitudo L. Item conſtituatur nervus in poſitione AF*p*CB, & ad punctum medium C erige normalem CS = radio Curvaturæ in C, & occurrentem Axi AB in D; & ſumpto puncto *p* ipſi C proximo, duc normalem *pc* & Tangentem *pt*.

Ergo

Ergo, ut in Lemmate 2, conſtat vim abſolutam quâ acceleratur particula pC, eſſe ad vim ponderis P, ut ct ad pt, i.e. ut pC ad CS. Sed eſt pondus P ad pondus ipſius particulæ pC, in ratione compoſita ex rationibus P ad N, & N ad pondus particulæ pC, vel L ad pC; hoc eſt, ut P×L ad N×pC. Quare compoſitis his rationibus, eſt vix acceleratrix ad vim gravitatis ut P×L ad N×CS. Conſtituatur itaque pendulum longitudine CD: tum (*per Princip. Math. Sect.* X. *Prob.* 52.) erit tempus periodicum nervi ad tempus periodicum iſtius penduli, ut $\sqrt{N \times}$CS ad $\sqrt{P \times}$L. At (per eandem Propoſit.) data vi gravitatis longitudines pendulorum ſunt in duplicata ratione temporum periodicorum; unde erit $\frac{N \times CS \times CD}{P \times L}$, vel (pro CS ſcripto $\frac{a\,a}{CD}$, *per Cor. Prob.* 1.) $\frac{N \times a\,a}{P \times L}$ longitudo penduli cujus vibrationes ſunt iſochronæ vibrationibus Nervi.

Ad inveniendam lineam a, ſit Curvæ abſciſſa AE = z, & ordinata EF = x, & ipſa Curva AF = v, & CD = b. Tum (*per Cor. Prob.* 1.) erit radius curvaturæ in F = $\frac{a\,a}{x}$. At dato $\dot{v}$ eſt radius curvaturæ $\frac{\dot{v}\,\dot{x}}{\ddot{z}}$.

Unde $\frac{a\,a}{x} = \frac{\dot{v}\,\dot{x}}{\ddot{z}}$; adeoque $a\,a\,\ddot{z} = \dot{v}\,x\,\dot{x}$: & ſumptis fluentibus $a\,a\,\dot{z} = \frac{\dot{v}\,x\,x}{2} - \frac{\dot{v}\,b\,b}{2} + \dot{v}\,a\,a$ (ubi additur data quantitas $\frac{-\dot{v}\,b\,b}{2} + \dot{v}\,a\,a$, ut fiat $\dot{z} = \dot{v}$ in puncto medio C.) Et hinc peracto calculo erit $\dot{z} = \frac{a^2\,\dot{x} - \frac{1}{2}\,b^2\,\dot{x} + \frac{1}{2}\,x^2\,\dot{x}}{\sqrt{a^2\,b^2 - a^2\,x^2 - \frac{1}{4}\,x^4 - \frac{1}{4}\,b^4 + \frac{1}{2}\,b^2\,x^2}}$. Evaneſcant jam b & x reſpectu a, ut coincidat curva cum axe, & fiet $\dot{z} = \frac{a\,\dot{x}}{\sqrt{b\,b - x\,x}}$. At centro C & radio CD = b deſcripto quadrante circulari DPE, & facto CQ = x, & erecta normali QP, atque arcu DP exiſtente y, erit $\dot{y} = \frac{b\,\dot{x}}{\sqrt{b\,b - x\,x}} = \frac{b}{a}\,\dot{z}$. Fig. 174.

Unde $y = \frac{b}{a}\,z$, & $z = \frac{a}{b}\,y$. Et facto $x = b = CD$, (quo caſu etiam fit y = arcui quadrantali DPE, & z = AD = $\frac{1}{2}$L) erit $\frac{1}{2}$L = $a \times \frac{DE}{CD}$, atq; $a = L \times \frac{CD}{2DE}$ Sit ergo CD ad 2DE (ut diameter circuli

culi ad circumferentiam) ut d ad c; atq; erit $aa = LL \times \frac{dd}{cc}$. Subſtituto itaque hoc valore pro aa, erit $\frac{N}{P} \times L \times \frac{dd}{cc}$ longitudo penduli iſochroni ipſi Nervo. Sit ergo D longitudo cujus tempus periodicum eſt 1, atque erit $\frac{d}{c}\sqrt{\frac{N}{P} \times \frac{L}{D}}$ tempus periodicum Nervi. Q. E. I. Sunt enim pendulorum tempora periodica in dimidiata ratione longitudinum.

Cor. 1. Numerus vibrationum Nervi in tempore unius vibrationis penduli D eſt $\frac{c}{d} \times \sqrt{\frac{P}{N} \times \frac{D}{L}}$.

Cor. 2. Ob datum $\frac{d}{c} \times \sqrt{\frac{1}{D}}$, tempus periodicum Nervi eſt ut $\sqrt{\frac{N}{P} \times L}$. Et dato pondere P eſt tempus ut $\sqrt{N \times L}$. Item conſtitutis Nervis ex eodem filo, quo caſu fit N ut L, eſt tempus ut L.

The Invention of making Clocks to keep Time with the Sun's apparent Motion, aſſerted by Mr. J. Williamſon, n. 363. p. 1080.

IX. In a *French* Book lately publiſhed the Author ſpeaks of making Clocks to agree with the Sun's apparent Motion; and ſuppoſed that it was a thing never thought of by any before himſelf: I ſhall therefore give this ſhort Account of what I have performed in that Matter my ſelf.

And in the firſt Place I muſt take Notice of the Copy of a Letter in this Book, wrote by one *P. Kreſa* a *Jeſuit*, to one Mr. *Williamſon*, Clockmaker to his *Imperial Majeſty*, of a Clock found in the late King *Charles* the *Second* of *Spain*'s Cabinet, about the Year 1699 or 1700. which ſheweth both equal and apparent Time according to the Tables of the Equation; and which went 400 Days without winding up. This I am well ſatisfied is a Clock of my own making; for about ſix Years before that Time, I made one for Mr. *Daniel Quare*, which agrees with the Deſcription he gives of it, and went 400 Days as he ſaith. This Clock Mr. *Daniel Quare* ſold, ſoon after it was made, to go to the ſaid King *Charles* the *Second* of *Spain*: And it was made ſo, that if the *Pendulum* was adjuſted to the Sun's mean Motion, the Hands would ſhew equal Time on two fixed Circles, on one the Hour, and on the other the Minute. But there were other two moveable Circles of the ſame kind, that moved forwards and backwards, as the Time of the Year required; on which the ſame Hands ſhew apparent Time likewiſe

likewiſe, according to the Equation Tables. This Method the Author owns he knew of, and applied the ſame Motion to Pocket Watches 12 or 14 Years ago, which I confeſs I never did; being well ſatisfied that Watches with Springs and Ballances are very unfit to ſhew the minute Difference, as it increaſeth and decreaſeth, between equal and apparent Time.

Soon after this Clock was ſent to *Spain*, I made others for Mr. *Quare*, which ſhewed apparent Time by lengthening and ſhortening the *Pendulum*, in lifting it up and letting it down again, by a Rowler ſomewhat in the Form of an *Ellipſis*, through a Slit in a Piece of Braſs, which the Spring at the Top of the Pendulum went through. By this Means every Vibration of the *Pendulum*, would agree to a ſecond of Time of the Sun's apparent Motion; that Rowler, which lifted up the *Pendulum*, and let it down again, being continually moving about all the Year; ſo that it may ſeem very ſtrange, that this Author never heard of it ſo many Years after they were made: For one of thoſe, and not the firſt, made with the riſing and ſetting of the Sun, Mr. *Quare* ſold to the late King *William*, and it was ſet up at *Hampton-Court*, where it hath been ever ſince. This Contrivance of lengthening and ſhortening the *Pendulum*, I thought of ſeveral Years before I made any of them. Since then I have made others for Mr. *Quare* likewiſe, which ſhewed the Difference between equal and apparent Time according to the Equation Tables, by a Hand moving both Ways from the Top of a Circle; on one Side ſhewing how much a Clock, keeping equal Time, ought to be faſter than the Sun; on the other Side how much ſlower.

But theſe Clocks that I then made to agree with the Sun's apparent Time, were done according to the Equation Tables, which I found not to agree very exactly with the Sun's apparent Motion: Neither can any other be made to keep equal Time, that will gain and loſe all the Year agreeable to the ſaid Tables; for though the Tables themſelves may be true, yet ſome Difference in Motion does proceed, in both ſorts of Clocks, from Cold or Heat altering the Length of their *Pendulums*. This Difference, by ſome Obſervations I have made, I ſuppoſe to be about the $\frac{1}{100}$ Part of an Inch, in the length of a *Pendulum* vibrating Seconds, which will alter the Motion of the Clock about 12 Seconds in 24 Hours. But to make my Clocks of keeping apparent Time, to go as exact as poſſible, I made a Table my ſelf by Obſervation: For obſerving the Sun, as often as it was ſeen, when it came on the Meridian, for ſeveral Years together, always ſetting down the Difference between its coming to the Meridian and the Time, by a Clock I had adjuſted as well as I could to equal Time, and always taking Notice how much my Equal-Time Clock gain'd or loſt at the End of every Year, I compleated my Table in the Year 1711. Since then I have made many of theſe Clocks: So that I think I may juſtly claim the greateſt Right to this Contrivance, of making Clocks to go

with apparent Time; and I have never yet heard of any ſuch Clock ſold in *England*, but what was of my own making, though I have made of them ſo long.

Experiments and Obſervations on the Motion *of* Sound, *by Mr.* W. Derham. n. 313. p. 2.

X. 1. Diſſenſus inter Authores celeberrimos de Soni Velocitate facili intuitu in ſequente Tabellâ conſpici poteſt: in qua (Pedibus Anglicanis) Spatium exhibetur quod Sonorum Progreſſui in uno Minuto Secundo Temporis aſcribunt.

Pedes.

D. *Iſ. Newton* Eq. Aur.	968	Prin. Ph. Nat. Math. L. 2. Prop. 50.
Nobilis D. *Roberts*	1300	Philoſ. Tranſact. N. 209.
Nobilis D. *Boyle*	1200	Eſſay of Languid Motion, p. 24.
D. *Walker*	1338	Philoſ. Tranſact. N. 247.
Merſennus	1474	Baliſtic. Prop. 39.
D. *Flamſteed* & *Halley*	1142	
Florentini celebres	1148	Exp. per Acad. *del Cimen.* p. 141.
Galli celebres	1172	*Du Hamel* Hiſt. Acad. Reg.

Inter ultimum & penultimum diſſenſus non eſt magnus, & *Gallorum* non multò major; cæterorum vero magnus eſt. Et ratio manifeſtè hæc eſt; vel ſcilicet ab Inſtrumenti defectu, vel à Diſtantiâ, vel à Ventis.

1. *Inſtrumentum*, quo nonnulli dimenſi ſunt, non fuit *Automaton*, ſed *Bolis funipendula*, quæ Minuta ſecunda vibrat. Sed manifeſtum eſt, Bolidem multò minus commodam eſſe, nec tam accuratam ac Automaton; quoniam neceſſarium eſt, Oculum primò occupatum eſſe in obſervando Coruſcationem, deinde ad Bolidem, ſive Pendulum reſpicere: quod tempus conterit, & confuſionem creat. Præſertim ſi,

2. *Intervallum* inter rem ſonantem, & obſervatorem parvum fuerit. At vero manifeſtum eſt, quòd plerique iſtorum Experimenta ſua fecerunt ad intervallum tantùm paucorum Pedum, & per Soni reditum, ſive Echo dimenſi ſunt. Horum enim nonnulli vix ultra 6 vel 700 pedes menſurationem extendebant, aliique non ultra Milliare unum. Sed ſemper obſervavi ambiguitatem oriri in tam parvâ diſtantiâ, quamvis optimum adhiberetur Inſtrumentum. Errorque leviſſimus in tantillis diſtantiis, magnus eſt habendus. Nam Pendulum forſan dimidium ſui diadromi, ſive arcûs, præteriit ab ultimâ pulſatione, cùm Sonus primò fuerit emiſſus: Sed nos iſtum Pulſum numeramus, ac ſi vibratio fuiſſet tota & completa; vel forſan Vibrationem anticipamus. Et poſtquam Sonus nos pertigit, forſan plus vel minus quam par eſt numeramus.

Vel

Vel ſi Diſtantia ſat fuerit longa, tamen error exinde poteſt oriri, ſi

3. *Ventorum* ratio non ſit habita.

Hæc ſunt certa incommoda, quæ Menſurationem progreſſus Sonorum comitantur.

Sed obſervari poteſt, quod Spatia à tribus ultimis in Tabellâ Obſervatoribus aſſignata, quam proximè conveniunt. Quod proculdubio hinc provenit, quia nempe bonis Automatis inſtructi fuerunt. In quorum uſu, *Auris* ſola occupatur in Vibrationibus Penduli excipiendis, dum *Oculus* attendit Coruſcationem, ſive aliquam aliam Soni emiſſionem. Hæ quoque Obſervationes intervallis longinquis factæ fuere, in quibus error puſillus non magni erit. *Flamſteedii* & *Halleii* Obſervationes factæ ſunt ad intervallum trium ferè milliarium (paucis Perticis plus vel minùs exceptis) ab Obſervatorio Regio, ſuper Collem *Shooterianum* : & Sonus advenit in 13 $\frac{1}{2}$ Secundis Temporis. Nobiles iſti *Florentini* & celeberrimi ex *Acad. del Cimento* ad idem fere intervallum Experimenta ſua fecerunt ; & quædam ad intervallum unius tantùm Milliaris. Et *Caſſini*, *Picard*, & *Roëmer* ad intervallum 1280 Hexapedarum Gallicarum, quod eſt plus quam 1 $\frac{1}{2}$ Milliare Anglicanum.

Ipſe experimenta plurima ad varia intervalla feci ; Scil. ab uno, ad 12 milliaria, & plura. Et ad Tempus dimetiendum, habeo accuratiſſimum *Automaton portabile*, cum Pendulo Semiſecunda vibrante.

Sequentes Quæſtiones à meipſo diſcutiendas propoſui.

1. Quantum Spatium Sonus percurrit in Secundo Minuto Temporis, vel alio Temporis intervallo ?

2. An Sclopus verſus Obſervatorem diſploſus, in eodem temporis intervallo Sonum mittit, ac cùm in contrariam partem diſplodatur ?

3. An in quolibet Atmoſphæræ ſtatu, cum Mercurius in Barometro aſcendit vel deſcendit, Soni percurrunt idem Spatium in eodem Temporis intervallo ?

4. An Soni velociùs Die quàm Nocte moventur ?

5. An Ventus favens Sonum accelerat, & adverſus retardat ? Sive an, & quomodo, Venti Sonum afficiunt ?

6. An tranquillo Cælo Sonus velociùs movetur, quàm Vento flante ?

7. An vehemens Ventus in tranſverſum flans accelerat an retardat motum Soni ?

8. An Soni eundem habent motum Æſtate ac Hyeme, Die ac Nocte ?

9. An etiam in Nivoſo, ac Sudo Cœlo ?

10. An Sonus magnus & exiguus eundem habent motum ?

11. An in omnibus Sclopeti elevationibus, viz. Horizontali, 10 gr. 20 gr. ad 90 gr. Sonus in eodem temporis intervallo Obſervatoris aurem pertingit ?

12. An omnimodi Soni, Sclopetorum, Campanarum, Malleorum, &c. eundem habent motum ?

13. An

13. An variæ Pulveris Pyrii vires motum Soni variant?

14. An in Culminibus Montium altorum, & Vallibus; ſive in ſummis Atmoſphæræ partibus, & imis, Soni idem percurrunt Spatium in eodem Temporis intervallo?

15. An Sonus acclivis & declivis eundem habet motum? Sive an à Jugo Montis deſcendit in Radicem eodem paſſu, ac à Radice aſcendit in Jugum?

16. An Sonus principio velociùs, & in fine tardiùs movetur, ut in plurimis aliis motibus violentis accidit?

17. Annon potius ſit æquabilis? Nempe; Annon in dimidio Temporis, dimidium Spatii; in quartâ parte Temporis, quartam partem Spatii, &c. movetur?

18. An in omnibus Regionibus, Septentrionalibus, & Auſtralibus, in *Angliâ*, *Galliâ*, *Italiâ*, *Germaniâ*, &c. eundem habent motum?

19. An Sonus rectà, ſive breviſſimo itinere, à loco in locum tranſit; an ſecundum ſuperficiem interjacentis telluris?

Ad hæc determinanda Amicos petii, ut Sclopos ex Turribus, aliiſque locis eminentibus diſploderent, ad intervallum 1, 2, 3, uſque ad 8 millia paſſuum (quod maximum eſſe intervallum reperi, ex quo Sclopi Sonum audire potui in his partibus, arboribus, &c. obſitis.) Hæc Sclopeta magno mihi fuerunt uſui. Sed Tormenta, quæ maximè propoſito inſerviebant, bellica illa fuerunt apud *Blackheath* [*Sakers* vocata] quæ exercentur in educandis Tyronibus Tormentariis. Horum Tormentorum micantes flammulas ex Eccleſiæ meæ turre videre, & fragorem audire potui in omnibus ferè cœli tempeſtatibus; etiam interdiu, ope Teleſcopii. Ideoque cum omni curâ & diligentiâ me ad horum Tormentorum obſervationem accinxi, uſque à *Februario* $170\frac{4}{5}$.

Poſt paucas obſervationes inter eorum diſploſiones factas, ſpeciale quoddam experimentum faciendum comparavi. Duo Tormenta bellica (*Sakers* vocata) juxta ſe ſita ſunt, adverſo unius ore, averſo alterius. Hæc duo Tormenta *Feb.* 13. $170\frac{4}{5}$. diſploſa fuere, unaquâque Semihorâ ab Horâ ſextâ pomeridianâ ad mediam noctem, leni aurâ directè adverſus Sonum ſpirante. Temporis intervallum inter Coruſcationem ſinguli Tormenti (quam nudo oculo videre potui) & Soni adventum, ſemper fuit circiter 120 vel 122 Semiſecunda Temporis. Dixi 120 vel 122, quoniam Sonus duplicatus advenit; ſcil. prior Sonus intra 120 Semiſecunda (qui languidior) ſecundus intra 122 (qui intentior.) Et eodem modo, per totum obſervationis tempus, ſingulorum Tormentorum fragor advenit, nempe duplicatus.

Hæc Reduplicatio Soni mihi videtur Echo, repercuſſa, ut opinor, à *Molendino Blackheathenſi*, vel Domibus juxta ſitis. De quo nullam habeo dubitandi rationem, præter ſententiam contrariam Amici cujuſdam docti, qui credit nullam Echo audiri, niſi quæ facta eſt per Objecta Phonocamptica non procul ab Obſervatore, non per ea prope Vocale, ſive Sonorum, vel alia longinqua Objecta.

2. Hoc

Of an Echo *at a* Great *Diſtance.*

2. Hoc autem Legibus *Echûs* non contrarium credo. Deinde notandum eſt, hunc duplicatum Sonum directè à *Blackheath* veniſſe : neque enim prior Sonus inde veniebat, & alter *(Echûs* more) aliunde ; nempe ultra me, vel à dextrâ, vel ſiniſtrâ, vel ab ullâ aliâ parte. Idemque ſæpiùs obſervavi, cùm Tormenta magna è Navibus diſploderentur in *Fluvio Thameſi* (præcipùe ſi aer fuerit ſerenus & tranquillus) veſperi & mane, cum Tormenta Vigilaria (Anglicè *Watch-guns)* exonerarentur. Poſtquam Fragor Tormenti aurem pertigit, audivi eum longè percurrentem ſecus Fluvium, & à Ripa, Montibus, & Scopulis (juxta littus *Cantianum* confertim ſitis) per plura Milliaria reboantem.

Hæc omnia, inquit Amicus, à Repercuſſione Domuum, &c. prope Te, proveniunt. Sed ne quid de Debilitate Soni dicam, poſtquam plurima Milliaria percurrit, & de ejuſdem incapacitate, ſi tam procul veniſſet, ut repelleretur per Objecta Phonocamptica juxta Obſervatorem, potiùs quàm per Objecta Phonocamptica juxta Sonorum ſita ; Exemplum autem unum vel alterum dabo, unde conſtabit, quòd Echo facta per Objecta Phonocamptica prope Rem vocalem ſive ſonantem, poteſt per plura milliaria audiri, æquè ac primarius Sonus, aliquando etiam eodem intentior.

Sæpè obſervavi Tormenta magna bellica e Navibus in *Thameſi Fluvio* veſpere diſploſa circa loca vocata *Deptford* & *Cuckolds-Point*, plerumque fragorem edere duplicatum, triplicatum, quadruplicatum, vel adhuc amplius multiplicatum ; & quòd Fragores poſteriores ſunt magis ſonori. Et cum hinc & illinc Stadium, etiam quadrantem vel dimidium Milliaris in tranſverſum ivi, Sonus tamen idem fuit. Memini quod octavo Martii noviſſime elapſi plurimæ Bombardæ magnæ diſploſæ fuere alicubi inter *Deptford* & *Cuckold's-Point* prædictas, è Nave quam in *Thameſi* ex meâ Eccleſiâ proſpexi. Harum fragor quinquies vel ſexies hoc modo repetitus eſt . Inter Coruſcationem & Sonum 122 Semiſecunda numeravi Vento in tranſverſum flante. Tunc temporis ideo Tormenta à me diſtabant plus quam 13 millia paſſuum. Duo primi crepitus languidiores erant quam tertii ; ſed crepitus ultimi omnium maximè ſonori. Et cum à dextrâ quadrantem milliaris tranſiviſſem, idem fuit multiplicatus Sonus : & cum à ſiniſtrâ, idem. Et præterea in aliquibus meis Stationibus, præter multiplicatum Sonum, planè audivi languidam Echo ab Eccleſiâ meâ, ſive Domibus adjacentibus repercuſſam : quod ſæpenumero tunc obſervavi, quoties Tormenta diſploſa fuere.

Alia hujus generis Obſervatio fuit quodam die Dominico, circa biennium vel triennium abhinc, ex ſono Tormenti magni militaris diſploſi alicubi in *Thameſi Fluvio* cis vel trans Oppidum *Graveſend* vocatum. Hujus Tormenti fragor fuit multiplicatus ad minimum octies, novies

novies, vel decies, ſecundum hanc temporis menſuram,

Hunc multiplicatum Sonum plurimi putabant eſſe Fragores multorum Tormentorum è Nave dimicanti: Sed, ut opinor, nil aliud fuit niſi Echo polyphona, ex unius vel alterius Tormenti diſploſi Sono, à Navibus pluribus vel Littore juxta ſitis repercuſſo. Hunc etiam non ipſe ſolùm audivi, ſed etiam multi alii qui *procul* diſtabant. D. *Barret* domi ſuæ eundem repetitum Sonum audivit, ad intervallum 4 ferè milliarium ab *Upminſter*, ubi ipſe audivi.

Of an Eccho *in the* Air.

3. Adjiciam etiam Exemplum de *Repercuſſione Soni in Aere ab Aereis particulis.*

Cum audivi Fragores magnorum Tormentorum bellicorum, præcipuè in tranquillo & ſereno Cœlo, ſæpenumerò obſervavi *Murmur*, excelſè in aere, præceſſiſſe Crepitum. Et in *Nebulâ tenui*, ſæpe Bombardarum Sonum audivi in Sublime, ſupra caput, in aere per plurima Milliaria percurrentem; adeo ut Murmur iſtud per 15″ temporis perduraverit. Diutinum hoc Murmur, meo judicio, provenit à Particulis Vaporoſis in Atmoſphærâ ſuſpenſis, quæ curſui Undulationum Soni oppugnant, eaſque Obſervatoris auribus reverberant, indefinitarum Ἠχῶν more: quas *Murmur in aere* vocamus.

His ritè perpenſis, manifeſtum erit Echo longinquè factam poſſe audiri; & Reduplicationem iſtam prædictam fragoris Tormentorum *Blackheathenſium* procul dubiò veniſſe ab ipſo *Blackheath*, prout modò aſſerui.

No Variation *of* Sound *from the* Different *Elevation, or Direction of the* Gun.

4. Ut autem pergam ad Obſervationes meas de Sonorum *Progreſſu*. Quod de Sono Bombardarum *Blackheathenſium* ſuggeſſi, in omnibus aliis reperi, viz. Motum Soni nec velociorem nec tardiorem eſſe, ſive Tormentum verſus Obſervatorem, ſive è contrario diſplodatur.

In omnibus item *Sclopi poſitionibus*, Horizontali, Erecta; & in omnibus ejuſdem elevationibus, 10 gr. 20 gr. &c. nulla eſt variatio Soni. Adeo vera eſt illa de hâc re obſervatio Inclytorum iſtorum Virorum ex *Academiâ del Cimento Florentiæ.*

Pulveris Pyrii quoque Vis, ſive ſit fortis, ſive debilis, ejuſque major vel minor Quantitas, licet augeat, vel minuat Sonum, non tamen accelerat, aut retardat ejuſdem Motum.

The Motion *of* Sound *not* alter'd *by the* Alterations *in the* Air.

5. *Kircherus* dicit *ſe ſemper diverſam Soni celeritatem inveniſſe, diverſis temporibus, mane, meridie, veſperi, noctu.* Sed ego (meliore Chronometro fretus, & commodiore diſtantiâ) nunquam reperi celeritatem Soni eſſe diverſam his temporibus. In omni autem tempeſtate, ſive Cœlum ſit *Sudum* & *Serenum*, ſive *Nubiloſum* & *Turbidum*; ſive *Nix* decidit, ſive *Nebula* (nam ambæ fortitèr retundunt Soni Audibilitatem;) ſeu *Tonat*, aut *Fulgurat*; ſive *Æſtus* vel *Frigus* adurit; ſive *Dies*, vel *Nox* ſit, *Æſtas* vel *Hyems*; ſive *Mercurius* in *Barometro* aſcendit vel deſcendit; in omnibus quibuſcunque Atmoſphæræ mutationibus (Ventis tantùm exceptis) Motus Soni nec velocior, nec tardior eſt; tantùm magis vel minus

minús clarus eſt ex illâ Medii variatione. Quod forſan *Kircherum* ſagacem decepit.

Hinc ſeqnitur Concluſiones D. *Walker* à Doctoris *Plot*, *Kircheri*, & ſuis Obſervationibus deductas erroneas fuiſſe.

Sounds *produced from* Different *Bodies* Move *with the ſame Velocity.*

6. Licet *Kircherus* contra ſentiat, attamen non dubito quin omnium corporum Strepitus, Sclopetorum, Campanarum, Malleorum, &c. eandem Velocitatem habeant. Anno 1704. Pulſationes Mallei & Fragorem Sclopeti comparavi, ad Milliaris intervallum (maximum ſpatium ad quod Mallei ſonum audire potui) & reperi utrorumq; Sonum in eodem tempore adveniſſe: & quòd $\frac{3}{4}$, $\frac{1}{2}$, & $\frac{1}{4}$ ejuſdem Spatii pertranſiverunt in $\frac{3}{4}$, $\frac{1}{2}$, & $\frac{1}{4}$ ejuſdem temporis.

Quod ad Sonos *Intenſos* & *Languidos* attinet, non dubito, quin idem Spatium in eodem Temporis intervallo percurrant. Ut ex his Experimentis aliquâ ex parte manifeſtum erit.

Jan. 13. $170\frac{4}{5}$. Archibombardarius Arcis *Tilburienſis* meo hortatu diſploſit unum & alterum Sclopetum, & Tormentum magnum Militare, in quod injectum pulverem pyrium benè fiſtulaverat. Horum omnium Strepitus in eodem tempore ad me, tria circiter milliaria diſtantem, pervenit.

Archibombardarius quoque *Angliæ Sept.* 11. 1705. poſt Solis occaſum, in mei gratiam, diſploſit ſuper *Blackheath* nonnullos Sclopos (Anglicè *Muſkets*,) Tormenta magna bellicoſa (*Sakers* vocata,) & Pyrobola (Anglicè *Mortars.*) Sclopos exaudire non potui, propter magnam diſtantiam, vel quia aer non ſat ſerenus fuit. Sed Tormentorum & Pyrobolorum Sonos in eodem Temporis intervallo exaudivi, licet Fragor Pyroboli fuit multò torpidior & remiſſior, quam Tormentorum.

The Motion of Sound Uniform.

7. Quod ad *Æquabilitatem Motûs Sonorum.* Talem eſſe deprehendi, qualem *Academia del Cimento* dudum præfinivit. Soni quippe progrediuntur Dimidium Spatium in Dimidio Temporis intervallo; Quartam Spatii partem in Quarto Temporis intervallo; & ſic deinceps. Quod ex exemplis in ſequenti Tabellâ conſtabit.

Locus quo diſploſio facta fuit.	Penduli Vibrat. numerus.	Diſtantia Locorum. Trigonometricè.	Per Sonum.	Ventorum Tendentia.
		Milliaria.	Milliaria.	
Hornchurch Eccleſia	9	0, 9875		tranſverſo.
Okendon Bor. Eccleſ.	18 ½	2, 004	2, 0	tranſverſo.
Mola *Upminſterienſis*	22 ½ / 23	2, 4	2, 4 / 2, 48	favente. / nive : tranſv.
Warley parvæ Eccleſ.	27 ½	3, 0	2, 97	forte favente.
Rainham Eccleſ.	33 ¼	3, 58	3, 59	tranſverſo.
Mola *Alveleientis*	33	3, 58	3, 57	tranſverſo.
Dagenham Eccleſ.	35	3, 85	3, 78	favente.
Weal Auſtrin. Eccleſ.	45	4, 59	4, 86	tranſverſo.
Thorndon Orient. Ecc.	46 ½	5, 09	5, 03	paulò fav.
Barking Eccleſia	70 ½	7, 7	7, 62	favente
Tormenta *Blackheath*	116	12, 5	12, 55	tranſverſo.

Intervalla Locorum ab *Upminſter* (ubi obſervavi) in hâc Tabellâ notata, quantâ potui accuratione dimenſus ſum vel Virgâ Menſuratoriâ, vel Arte Trigonometricâ. Et ex magnâ conſonantiâ inter intervalla hoc modo, eademque per Soni motum dimenſa, cùm Inſtrumentorum meorum præſtantia, tùm Obſervationum & Calculorum veritas patet. Differentia enim inter Intervalla dimenſa, & eadem Sono capta, aut prorſus nulla eſt, aut tantùm paucularum centeſimarum partium, niſi cum Ventus fuerit ſecundus (Eccleſiâ *Weal Auſtrinæ* exceptâ, de quo poſthac.) Ita nempe in Obſervationibus ex Eccleſiis *Dagenhamenſi*, *Warleienſi*, *Thorndonienſi*, & *Barkingenſi* factis, diſtantiæ per Sonum notatæ paulò breviores viſæ ſunt; quia Ventus Sonum acceleravit. At in conficiendâ hâc Diſtantiarum per Sonum Columnâ, nihil propter Ventorum accelerationem conceſſi; ſed numerum Vibrationum, ſive Semi-ſecundorum tantùm diviſi per 9 ¼, vel 9,25 (numerum Semi-ſecundorum in quibus Sonus Mille paſſus tranſit.)

Æquabilitas quoque motûs Soni ex hâc Tabellâ manifeſta eſt; prout patebit ex collatione Vibrationum & Diſtantiarum: ſive ex ſolâ Columnâ Diſtantiarum per Sonum.

Ut autem nihil deeſſet in harum rerum confirmationem, iter feci ad *Arenas Foulneſianas* in littore noſtro *Eſſexiano*. Hæ Arenæ (Maris quotidiano Æſtu allutæ, & obtectæ) faciunt magnam & exactam Planitiem multorum milliarium. Super hanc Planitiem tantùm ſex milliaria dimenſus ſum, quia neque Maris æſtus, neque mora mea, ut majus intervallum dimetirer, permitterent. Ad cujuſque ferè Milliaris finem experimenta feci per Sclopetorum Exploſionem. Ex quibus Experimentis comperi Obſervationes meas priores omnes juſtiſſimas, & veras fuiſſe,

fuiſſe, ſcilicet Sonum unum Milliare pertranſire in 9 $\frac{1}{4}$ Semi-ſecundis: duo Milliaria in 18 $\frac{1}{2}$ Semi-ſecundis: tria Milliaria, in 27 $\frac{3}{4}$ Semi-ſecundis, & ſic deinceps.

8. Quod ad 15 & 19 Quæſita attinet; fateor me nunquam ullis quæ feci hactenus Experimentis mihimet ipſi ſuper his rebus ſatisfeciſſe. *Of the* Aſcending *and* Deſcending *of Sounds, &c.*

Et primò de Progreſſu Soni per breviſſimam viam, in Quæſ. 19. Ratio de hoc dubitandi fuit diſcrepantia inter Spatium *Weal* Villæ & *Upminſter* Trigonometricè, & per Sonum dimenſum; prout in Tabellâ præcedenti exhibetur. Menſuratio Trigonometrica tot modis, & tam bonis Angulis capta eſt, ut de eâ nullus dubitem. Sed quoniam per Soni motum diſtantia major videtur, & Superficies interjacentis Soli hujuſmodi formam induit, qualis in *figurâ* 175 exhibetur; ideo ſubdubitavi annon paululum tortuoſe Sonus vagatur? ſive annon Acclivitas illa interjacens in *(A)* Soni Undulationibus oppugnando retundit, eaſque tardat? Fig. 175.

Ut nodum hunc quodammodo ſolverem, Experimentum fieri curavi, Sono Sclopi à Cacumine *Collis Langdonienſis* in Vallem ſubjacentem, ad intervallum 3,79 millia paſſuum. Intervallum Trigonometricè, ex Angulis & Baſi ſat magnis, benè dimenſum eſt; & Experimentum factum, cum lenis aura paululum Sono oppoſuerit. Inter Coruſcationem & Crepitum 35 $\frac{1}{2}$ Semi-ſecunda numeravi. Qui numerus ad intervallum adeo quadrat, & cum cæteris experimentis tam proximè convenit, ut non dubitandum ſit, quin Sonus à Cacumine in vallem rectà (per aerem) deſcenderit, & non juxta Superficiem curvatam interjacentis Soli.

Errorem igitur aliqualem fuiſſe credo in Obſervationibus *Wealienſibus* prædictis, quoniam nec in Experimento noviſſimo *Langdonienſi*, neque in ullis aliis, tale aliquid obſervavi.

Quod ad Soni Motum ſurſùm & deorsùm attinet; an ſcilicet pari tenore eodemque gradu à Montis cacumine ad Radicem, & retrorſum ferantur? Vix ſpero me unquam mihimet, vel aliis ſatisfacturum. Neque enim *Eſſexiæ*, neque conterminis partibus, ſat alti Colles occurrunt, unde quis ſatis Experimentorum in hunc finem inſtituat. Quippe omnium altiſſimi, quos huc uſque videre contigit (quales ſunt ii quos *Langdonienſes* vocant) Semiſſem Stadii non multum ſuperant. Jugum enim editiſſimum ejuſdem dimenſus ſum tum Trigonometricè, tum Barometro portatili. Illudque, priore modo, 363 pedes altum eſſe reperio, poſteriore modo . . . . .

Superiore autem Æſtate, cum in Occidentales Regni plagas iter facerem, Colle quodam, cujus Altitudinem paucis abhinc annis trium circiter Stadiorum fuiſſe (ni fallit memoria) dimetiendo compertus ſum, experiri volui. Quo tempore, Ventus tranſverſim, ſed tam leniter ſpirabat, ut candelam accenſam haud extingueret, Sclopeta quædam & ad Radicem & Jugum Montis diſplodi juſſi; Sonumque eodem ferè temporis intervallo utrinque pervenire ſenſi. Si quam leviculam

culam diſcrepantiam obſervavi, in hoc conſiſtere videbatur, nempe quod Sonus aliquantò citiùs in montem aſcenderet, quam ab eodem deſcenderet.

Sed vix potui eâ quâ par eſt ἀκριβείᾳ tempus dimetiri, quippe infeliciter evenerat, ut ipſum Chronometrum, aliquantulum, itineris concuſſione, turbaretur. Hoc itaque Experimentum aliis felicius, & certius capiendum relinquo. Atque utinam quidam hoc ipſum ad *Alpes* experiri vellent.

Motion *of Sounds in* Italy.

9. Obſervationes quædam & Experimenta, in mei gratiam, in *Italia* facta a doctiſſimo D. *Doctore Newton*.

Richardus Townleius Armiger, Literis ad me datis Anno 1704. ſignificaverat, "Sonos rarò exaudiri *Romæ* tam longè ac in *Angliâ*, noſtriſ-
" que *Borealibus Regionibus*. Speciatim vero aiebat, Se, cum *Romæ*
" commoratus eſt, dum Bombardæ quædam *Caſtelli S. Angelo vocati* diſ-
" ploderentur, atque ipſe ſuper Montem *Trinitade* dictum ſtaret, ob-
" ſervâſſe Sonum multò languidiorem eo loci fuiſſe, quàm in ullo alio
" ad eandem diſtantiam ſito." Et poſt ejus mortem, Frater ejuſdem mihi Scripto retulit, quod Anno 1688; " Cùm relictâ *Româ* ad *Caſtel-*
" *lum Gendolpho* (eminentiorem quendam locum prope *Lacum Albanum*,
" duodecim circiter Italica Milliaria à *Româ*) ſe contulerit, animadver-
" tiſſe ſonum Bombardarum magnarum à Caſtello (prædicto) *St. Angelo*
" obſtrepentium, ſibi tamen imminutum & debilem videri. Alio
" quoque tempore, cùm Currus circa prædicti Caſtelli mænia veheretur,
" Bombardæque ingentes exinde boarent, nec talem tantumve Sonum
" ibi loci ac alibi emittere videbantur.

Cùm hæc à duobus hiſce viris animadverterentur, ipſumque Phænomenon novum prorſus & inuſitatum videretur, inceſſit animum cupido quærendi, quænam iſtius foret cauſa. Literas ergo ad clariſſimum *D. Doctorem Newton* dedi; qui, quid Ipſe, quid item Amici ſuper hâc re obſervaverunt, menſe *Octobri* 1706, reſcripſit.

Narrat autem quod in itinere à *Bononia*, *Florentiam* verſus, Bombardarum exoneratarum ſtrepitum ad *S. Michaelis in Boſco* urbem (in *Bononiæ* viciniâ) exaudiverit, quæ tamen Bombardæ *Mirandulæ* diſploſæ ad 40 millia paſſuum diſtabant; quem locum *Gallorum* acies obſidione tum cinxit. Ac nocte inſequenti eundem Sonum, cùm in *Apenninis* pernoctaret (20 millia paſſuum longiùs remotus) exaudiverit.

Cum noſtras Literas *Florentiæ* acceperit, Nobili cuidam, quid vellemus, aperuit: qui deinceps hæc Vota noſtra *Magno Duci* nota fecit. " Idem verò *Magnus Dux* (uti inquit) Experimenta ſtatim fieri juſſit,
" unde mihi plenè de hâc re ſatisfieret:" *Joſephumque Averrani*, inclytum *Piſæ* Philoſophum, hiſce Experimentis inſpiciendis & dirigendis præfecit. Summatim huc redit.

" Quod in hâc inferiori *Florentiæ* arce, Bombarda *Colubrina* inter ho-
" ras primam & tertiam Noctis crebrò diſplodebatur; Virique quidam
" *Ligurni* aſſervabantur, qui diligenter obſervare juſſi ſunt, an ejuſdem
" crepitum exaudire poſſent. Quorum nonnulli qui ad *Lanternam*, &
" *Marzocco*

" *Marzocco* poſiti erant, nullum audiebant, (fortè quia Maris fremitus
" Sonum infuſcabat:) alii vero qui ſtabant ſuper *Veteris Arcis* muni-
" menta (quæ *Donjon* appellant) quique ad *Montem Rotondo* dictum (qui
" quinque circiter milliaria à *Ligurno* abeſt verſus *Montem Nero)* miſſi,
" auribus exceperunt. Et quotieſcunque exonerabatur, toties ejus fra-
" gor iiſdem in locis clarè exauditus eſt. Hujus autem *Arcis Florentinæ*
" diſtantia à *Monte Rotondo* rectâ lineâ vix minor 55 milliaribus cenſetur.
" Et notatu dignum eſt, quòd interjacentia rura pleriſque collibus obſita
" ſunt, qui paulo impeditiorem Soni viam reddant, neceſſe eſt. His ac-
" cedit, quòd eodem veſpere ventus quidam Occidentalis leniter ſpira-
" bat, qui (cum *Ligurnus* ſitus ſit ad Libonotum reſpectu *Florentiæ)* li-
" beriorem Soni expanſionem aliquatenus præpedire meritò credatur.

" Quo autem locus apertus haberetur, ſeligebatur tractus ille Maris
" *qui Ligurnum* & *Portum*, *Ferraio* dictum, interjacet, cujus diſtantia
" ſecundùm peritiſſimorum Nautarum calculum 60 milliarium eſſe de-
" prehenditur. Tormentorum autem militarium fragor à *Ligurno* ad
" prædictum *Portum Ferraio*, locaque vicina haud rarò pervenit. Nec
" aſpirantium Ventorum auxilio opus eſt, ad promovendum huncce Soni
" progreſſum, quo nempe exaudiatur. Imò verò ventus quilibet, ſive
" ſit ſecundus, ſive adverſus, eidem impedimento eſt, ipſumque Sonum
" minus ſonorum reddit: forſan quia Maris hinc agitati fremitus ma-
" gis obeſt, quam Aeris eodem confluentis curſus prodeſt. Proinde
" tunc ſolùm exauditur Sonus, cum Ventus prorſus ſilet, vel tantùm le-
" niſſimè ſuſurrat, cum Aer ſerenus eſt, & Mare tranquillum. Neque
" tum quidem ab omnibus locis indiſcriminatim exauditur, ſed ab iis
" ſolis quæ paulò eminentiùs ſita ſunt; cujuſmodi ſunt duo iſta propug-
" nacula, quæ *Stella* & *Falcon* nominantur & Locus *Mulini* dictus. Præ-
" terea requiritur, ut ipſe Obſervator quàm attentiſſimum ſe præbeat,
" nec ullâ obſtrepentium voce aut clamore impediatur & infeſtetur.
" Tum verò interdiu æquè ac noctu (modo Atmoſphæra ſit ſerena &
" tranquilla) exaudiat; niſi quod nocturno tempore fortior & acutior
" aliquantò videatur Sonus, cum nulli occurrunt Strepitus, qui diurno
" ſæpiùs aures offendere ſolent.

" Porro nobis nunciatum fuit a Teſtibus fide digniſſimis, quòd plu-
" ribus abhinc annis, cùm graſſaretur *Seditio Meſſanenſis*, ipſaque Urbs
" obſidione premeretur, Tormentorum bellicorum fragor *Auguſtæ* &
" *Syracuſanorum* Incolarum aures percelleret.

" Item cùm *Galli* Tormentis muralibus *Genuam* concuterent, conſtat
" quod eorundem crepitus ad *Montem* uſque *Nigrum*, qui *Ligurno* ſuper-
" eminet, pertigerit.

" Ex hiſce Obſervationibus proclives ſumus ad credendum nullum
" eſſe ſuper hâc re diſcrimen inter *Italiam* & *Plagas Boreales*.

" Quod autem ad alterum Quæſitum attinet; utrum ventus directè
" vel adverſè ſpirans, Sonum accelerat vel retardat? Eidem hactenus
" certò reſponderi haud poteſt. Sequentia tamen experimenta liceat
" proferre.

" *Colubrina* quædam (60) ſuper Cortinam inferioris propugnaculi " *Florentiæ* adducebatur, ibique ſic poſita ut Os ejuſdem verſus *Artemino* " ſpectaret (quod eſt Ruſticanum *Magni Hetruriæ Ducis* Palatium, colle " quodam altiore ſitum, prædictique Propugnaculi latus Occidentale " reſpiciens, à quo etiam circiter 12 millia paſſuum diſtat.) Diem " quendam ſelegimus cùm Ventus occidentalis aliquantò fortiùs ſpira- " ret, ut Soni motus contrario vento repellerentur. Hoc autem parum " juvabat: quippe ſub veſperam, cœlum omnino tranquillum erat, vel " ſaltem adeo tenui aura agitabatur, ut candelæ flammam haud disjiceret. " Hîc Loci relictis quibuſdam harum rerum peritis, ad prædictum *Pala-* " *tium Artemino* conceſſimus: inter Horas primam & tertiam Noctis, *Co-* " *lubrina* ſæpius exonerata eſt; & 49 Secunda Minuta inter ejuſdem " Coruſcationem & Fragorem jugiter numeravimus. Nos etiam in " *Artemino* Bombardas quaſdam accendimus; atque inter harum co- " ruſcationem & fragorem prædicti Spectatores (quos in Arce reliqui- " mus) tantùm 48 Minuta Secunda numeraverunt. Unde conſtabat " Sonum unius tantùm Minuti Secundi intervallo velociùs ab *Artemino* " ad *Florentiam*, quàm retrorſum ferri.

" Haud adeo noſtræ obſervationi confidimus, ut minutulum hoc Ve- " locitatis diſcrimen ad Venti conſpirantis aut renitentis vim referre au- " deamus. Quippe ipſius Obſervatoris error, qui Penduli vibrationes " numerabat, huic fortean occaſionem dederit. Quod ſanè facilè fieri " poſſit. Sæpius enim eveniat neceſſe eſt, ut emicantem flammam non " niſi poſt inceptam Penduli Vibrationem videat, Sonitûſque fragorem " nondum terminatâ Vibratione exaudiat: adeo ut ipſe Calculum unâ " Vibratione auctiorem, quàm par eſt, hoc pacto faciat, dum interea " Temporis ſpatium ſit utrinque par & idem.

" *Colubrinam* rurſus, cum illuxerit Dies, exonerari juſſeramus: Ven- " tus autem nec Votis nec Operi favebat; quippe qui paululum tantùm " ad Borealem plagam ſe convertiſſet. Adeo ut variatio Temporis, " & Velocitatis Soni, in tantillâ Venti mutatione, vix percipere- " tur. Solitas proinde 49 Penduli Vibrationes, ut prius, numera- " bamus.

Quod ad Spatium attinet, quod Soni quovis aſſignato tempore percurrunt, de eodem nondum inter ſe conſtat; ſed ab experimentis quibuſdam conjiciebat rem ita ſe habere, prout Experimenta *Academiæ del Cimento* teſtabantur.

Ex hiſce Obſervationibus, abundè patet, Multò longiùs exaudiri poſſe Sonos in *Italiâ*, quàm prædictus Amicus ingenioſus nos docuit. Ipſe enim eximius D. D. *Newton* Bombardarum ingentium ſtrepitum ad 60 Milliarium diſtantiam auribus percepit. Quæ etiam ejuſdem ſuaſu *Florentiæ* exonerabantur, eædem 55 Millia paſſuum audiebantur. Tormenta militaria *Ligurni* diſploſa ad 60 Milliarium intervallum aures feriebant. Quæ *Meſſanæ* exonerabantur eorum aures, qui (ut ex Tabulis Geographicis patet) centum fere Italica Milliaria ſemoti ſunt, percel-

percellebant. Quæ denique in concutiendâ *Genuâ* diſploſa ſunt, eorundem fragor plus quam 90 Millia paſſuum Italicorum (ut ex Mappis) pervenit.

Quibus omnibus perpenſis, vix poſſum quin credam, non minus latè propagari Sonos in omnibus *Meridionalibus*, quàm in hiſce *Borealibus* Terrarum plagis. Quamvis haud deſunt exempla longioris Sonorum progreſſûs in quibuſdam Septentrionalibus Terræ partibus. *Danus* quidam mihi narravit ſe, cum in *Daniâ* vitam ageret, Bombardarum *Carolſcrooniæ* diſploſarum crepitum, 80 Milliaria Anglicana (ni fallit memoria) remotum clarè exaudiviſſe. Peritiſſimus *Doctor Hearn* (illuſtriſſimi Regis *Sueciæ* Medicus) narrationem quandam ad *Regalem* noſtram *Societatem* miſit, de Bombardis *Holmiæ* exploſis, A. D. 1685; quarum fragor 30 Suevorum Milliarium intercapedinem percurrit, quæ 180 Milliaria Anglicana ferè exæquant. Navali etiam illâ Pugnâ quæ geſta eſt *Angliam* inter & *Hollandiam* A. D. 1672. Tormentorum bellicorum Strepitus plus quàm ducentis Milliaribus interjacentium aures percuſſit; quippe qui trans *Inſulam noſtram* ad *Salopiam* uſque & *Walliam* pertingebat.

Quod proinde Fratres *Townleii* obſervârunt, idem prædicto *Caſtello S. Angelo*, vel *Romæ* ſaltem, proprium omnino eſt, & peculiare. Iſta Soni diminutio, quam iidem animadvertebant, vel ad prædicti Caſtelli Situm, vel ad interjacentes Domos (paſſim & ubique in iſta confertiſſimâ Urbe ſurgentes) vel ad Strepitus ejuſdem undique perſonantes, vel ad Ventos adverſos, vel demum aliam conſimilem cauſam referendum eſt. Vel forſan ſuas Obſervationes fecerunt eo Aeris ſtatu, quo ſoni, quamvis maximè ſecundos habeant Ventos, multò tamen languidiores ſunt, quam aliis temporibus, cum prorſus adverſi ſunt.

Of the Remiſneſs *and* Intenſeneſs *of* Sounds, *according to the* Alteration *of the* Air.

10. Sæpius *Æſtate*, cùm jam incaluerit aer, obſervavi Sonos ſupra modum languidiores videri, debileſque admodum ad aures ferri; cùm aliâ tempeſtate, præſertim *Hyeme*, ſi forte gelaſcit, multò magis argutos & ſtridulos eoſdem fuiſſe, fortiúſque aures perculiſſe. Spirante etiam *Borea* vel *Euro* (quantumvis adverſè) Sonos clariores, magiſque ſtridulos eſſe ſenſi, quam ſi ex contrariis plagis Venti ſpirarent; ut *Kircherus* quoque *Romæ* obſervavit. Hoc autem non conſtans & perpetuum eſt.

Neque quid magis certum ex *Mercurii in Barometro* aſcendentis vel deſcendentis inſpectione colligerem. Sonos enim aliquando maximè claros & argutos, aliquando maximè debiles & languidos cùm ad ſummum aſcenderet; è contra aliquando maximè ſtridulos, interdum maximè deficientes, cum Mercurius ad imum deſcenderet, comperi.

Pariter etiam incertè ſe res habet quoad ſerenum & nebuloſum aerem. Tempore pluvioſo & humido ſæpè obſervavi Sonos obtundi, & "Poſt imbres vehementiores plurimùm virium acquirere, ut *Kircherus* "*Romæ*." Sed contrarium quoque ſæpe evenit. *Maii* 31. A. D. 1705. Aer hîc loci magis ſerenus, vaporumque expers fuit, quam unquam antea

tea me vidiſſe memini. Tam purum etenim liquidóque ſerenum erat Cœlum, ut objecta longiſſimè remota clarè faciléque proſpicerem. Sed tamen Bombardas in agro *Blackheath* tunc temporis exploſas exaudire non potui (ſi unam excipias, cujus fragorem jam prorſus languentem auribus perceperim), quamvis omnium eminùs micantem flammulam clarè cernerem. Eodemque tempore Nubium & Venti motus cum ſono conſpirabat; Aura etiam leniſſima tunc ſpirabat; omnia denique ad Soni vim motumque promovendum neceſſaria concurrere videbantur. E contra vero, cùm prorſus mutatus fuerit Aeris & Cœli ſtatus, cum omnia turbida viderentur, & Atmoſphæra vaporibus plena, ſæpe ſtridulos Sonos, nec minus crebrò eoſdem hebetes & remiſſos exaudivi.

Cauſas harum Variationum aliis inquirendas relinquo, quoniam noſtri ingenii captum eas æquè ſuperare fateor, ac aſſignare quid ſit proprium Soni Medium, ſive Vehiculum; an ætherea & ſubtilior, an vaporoſa & craſſior Atmoſphæræ pars, ſive ambæ ſimul?

Quod autem *Nebulas ſpiſſas* ſpectat, eaſdem certum eſt Sonos quam maximè hebetare. Soni enim tunc admodum languidi & obtuſi plerumque videntur. Quod ab interpoſitis vaporibus, & ſpiſſis particulis, quæ Nebulam conſtituunt, certiſſimè provenit.

Idem etiam de *Nivoſo Cælo* obſervavi. Cum enim Nix recens in terram decidit, protinus hebeſcunt Soni. Cum verò glaciata fuerit ejus ſuperficies, Soni repente acutiores fiunt. Campanaſque & Bombardas tinnientes & reboantes eo uſque exaudivi, ac ſi nix humum non conſperſerat. *Townleius* haud ita pridem ſe obſervaſſe aiebat (cui non abſimile egomet expertus ſum) dum per oppidum quoddam equo veheretur, Campanarum (quæ tum haud ita procul pulſabantur) Sonum ad aures vix poſſe pervenire, ſi quando Domus Nive tecta occureret interjacens. Adeo ut ipſe, oppidulum ingreſſus, plurimum miratus ſit, Campanas tam ſubitò ſilere, dum primas interjectas ædes prætergrederetur; deinde repente reſonare cum proximum vacuum intervallum præteriret. Quod quidem per totum viæ curſum in eodem oppido obſervavit; Campanarum nempe Sonum ad aures pertingere, vel non, prout ædificia nive obſita occurrerent interpoſita vel non.

Of the Influence of Winds *on the* Motion *of* Sounds.

11. Illuſtriſſima *Academia del Cimento* ab experimentis invenit Sonorum motum nec ab adverſis Ventis retardari, nec à ſecundis accelerari: Sed utcunque ſpirarent Venti, ſemper idem Spatium in eodem tempore percurrere. In iſtâ ſententiâ fuit *Gaſſendus*, cæterique fere omnes.

Contrarium vero patet ab ipſa Experientia. In errorem hunc ideo incidiſſe videntur, quod ad nimis breve intervallum Experimenta ſua inſtituerentur. Omnino enim veriſimile eſt hoſce Philoſophos ad unius tantùm, vel ad ſummum duorum, triumve Milliarium diſtantiam obſervationes ſuas feciſſe. Quas proinde vitioſas eſſe haud miror. Sin autem ad 10 aut 12 Millia paſſuum, accuratis Inſtrumentis adhibitis, rem tentaſſent (quod ipſe ſæpius feci) errorem facilè agnoſcerent.

Quem

Quem communem errorem Egomet (horum Virorum auctoritate fretus) diu admiſi; donec tandem Bombardarum in agro *Blackheath* obſervatione triennali, & ampliùs, eundem feliciter detexi. Cum autem primùm Sonos aliquando citiùs, aliquando tardiùs ad aures pertigiſſe ſenſi, erroris cujuſdam à me facti ſuſpicio animum ſubiit, vel quod Automati vibrationes minùs rectè numeravi, vel coruſcantem Bombardæ flammulam malè obſervavi; vel in alium conſimilem errorem haud attentus inciderim. Poſtquam verò Bombardæ de induſtria in mei gratiam exonerarentur ſingulis ſemihoris, ab hora ſexta veſpertina uſque ad mediam noctem, Sonumque perpetuò ſine ulla notabili varietate, 120 vel 122 ſemi-ſecundorum ſpatio pervenire ſenſi, quamvis Ventus directè adverſus fuiſſet; aliis autem temporibus, cum ventus ſecundus ſpiraret, ſive è directo, ſive ex tranſverſo, aut obliquo, earundem Bombardarum Sonum 111, 112, 113, 114, 115, 116 vel ad ſummum 117 Semi-ſecundorum ſpatio advenire deprehendi; tum demum me certiſſimè perſuaſum habui, reale aliquod diſcrimen fuiſſe, quod iſtam in Obſervationibus varietatem peperiſſet.

Neque ſolum *Secundi* aut *Adverſi Venti Sonorum motum accelerant aut tardant*, ſed etiam *pro graduum varietate, quo vehementiùs aut leniùs ſpirant, eò magis minuſve eundem promovent aut impediunt.* De quibus ſpeciales quaſdam obſervationes in ſequenti *Tabula* ſubnectam; poſtquam prænotavi Bombardas in agro *Blackheath* circiter 60 gradus à Meridie diſtare, hoc eſt ad Plagam à S W b W aliquanto remotiorem vergere.

Tabella Sonorum Bombardarum in Agro *Blackheath*, pro Ventorum, Viriumque, quibus agitantur, varietate.

Dies Menſis & Anni.	Hora Diei.	Numerus Vibrationum.	Ventorum Plaga.	Nubium Plaga.	Altitudo ☿.
1704					
Feb. 13	6 h. ad med. noc.	120 122	NEbE1	NEbE	29 99
21	11 ½ mane	119	E 2	E	30 22
1705.					
Mar. 30	10 mane	113	SW 7	SW	29 30
Apr. 2	8 ½ p. M.	114½	SbW 1		
3					
3	10 mane	116½	S 4	Inferior S Sup. WbN	29 80
5	1 p. M.	111	SWbW7	SW by W	29 70
13	8 ½ mane	120	NbE 2		29 26
24	5 p. M.	116	SWbW0	NW	29 59
Sept. 11	6 ½ p. M. 7 p. M.	115 115½	W 2 WbN2	WbN	Saker. Mortar
29	10 ½ mane	112	SSW 6	SSW	29 38
Octob. 6	10 mane	117	ESE 1&2	SE	29 34
Nov. 30	meridie	115	SSW 4	SSW	29 10
Febr. 15	11 mane	116	SbW 1	SW	29 60
1706.					
Nov. 29	11 ½ mane meridie	116 118	SW 0 SWbS1	SWbW	30 06
Febr. 7	meridie	113	SWbW4	W	29 83

Ex quam plurimis has Obſervationes ſelegi; omnes cautè factas; ſingulas nimirum bis, ter, aut ſæpius repetitas. Ita ab experimentis *Apr.* 5. & *Sept.* 29. factis, patet Ventos vehementiores urgere & maturare Sonorum motum: quinto enim *Aprilis*, cùm propè conſpiraret Venti Sonique motus, fortior etiam aliquanto idem Ventus fuerit (prout figura [7] annexa denotat, pariter ac Cifra [0] tranquillum Cœlum; & Fi-

& Figuræ 1, 2, 3, 4, &c. varias Ventorum vires ſignificant) tunc temporis, inquam, Sonus 111 Semiſecundorum ſpatio iter confecit. *Aprilis* autem 24, cum Ventus ab eâdem Plagâ ſpiraret, & aer tranquillus eſſet, idem itineris ſpatium non niſi 116 Semi-ſecundorum intervallo Sonus peragrâſſet. Ita etiam *Feb.* 7. 1706. cùm ab eodem Cardine ſpiraret Ventus, & ſecum deferret Sonum, viribus autem jam dimidio minoribus, 113 Semi-ſecunda elapſa ſunt priuſquam Sonus aſſuetum confecit iter. Ita demum *Sept.* 29. 1705. Vento vehementiore ſpirante, & minus ſecundo, Sonus intra 112 Semi-ſecunda progreſſum abſolvit. Ex quibus, aliiſque in Tabellâ exemplis liquidò conſtat, *Ventos fortiores Soni propagationem adjuvare, Leniores autem eandem minus promovere.*

Idem etiam conſtat de iis Ventis, ſive Aeris torrentibus, qui Soni progreſſui e directo favent, vel obſtant; eos nimirum *ejuſdem motum celeriorem vel tardiorem reddere.* Quique *Intermedii* volvuntur Atmoſphæræ fluxus, eos *Intermedium pariter ſoni progreſſum*, ſive Penduli Vibrationum numerum efficere.

Maximum diſcrimen, quod in Soni progreſſu per 13 fere milliarium ſpatium hactenus animadverti, novem circiter aut decem Semi-ſecunda exæquat, cum nempe Venti fortes promovent, & lenes tantùm impediunt Sonum. Cum verò tenues ſolum aut prorſus nulli obſtant, vel adjuvant eundem, tum quidem differentia duo vel tria Semi-ſecunda haud ſuperat.

12. Ut quantum ſpatium quovis aſſignato tempore perflent Venti pro certo ſcirem, leviuſcula quædam corpora in parandis experimentis adhibui. Cujuſmodi ſunt Pappus, Plumæ leves, &c. quæ propoſito melius inſervire videbantur, quam Inſtrumentum illud quod in *Actis Philoſophicis* †, N°. 24. deſcriptum habemus; vel etiam illud alterum magis commodum Molæ alatæ figuram referens, ab acutiſſimo D. *Doctore Hook*, ni fallor, excogitatum. *Of the* Velocity *of* Winds.

† Vid. Supra V. II. c. 1. S. XVII.

Ex plurimis quæ feci experimentis, leviuſculorum corporum ope, cum variæ Ventorum vires fuerint, deprehendi, Ventum vehementiſſimum vix 60 Millia paſſuum horæ ſpatio percurrere. Exempli gratiâ; *Aug.* 11. 1705. tantam procellam excitavit Venti vehementia, ut ipſam Molam Pneumaticam, juxta locum quo obſervationes meas feci, pene ſubverteret. [Ventorum Vires (uti modi diximus) hiſce Characteribus plerumque notavi; 0, 1, 2, 3, 4, 5, 6, uſque ad 10, 15, aut plures gradus.] Prædicti autem Venti Vires 12 circiter aut 14 graduum horum reſpondere æſtimavi: & à quamplurimis iteratis experimentis animadverti, Turbinem iſtum circiter 33 pedes, ſpatio Semi-ſecundi Minuti percurrere, ſive 45 Milliaria in Hora. Unde colligo Ventum concitatiſſimum & maximè nimboſum (illo vehementiſſimo, qui Menſe *Novembris* 1703. furebat, haud excepto) non plus quam 50 aut 60 Millia paſſum horæ ſpatio prætervolare.

Poſtquam rapidorum Ventorum Velocitatem dimenſi ſumus, quæ ſit minùs rapidorum celeritas conjicere, haud difficile eſt. Horum enim curſus pariter notavi, variiſque ab Experimentis edoctus ſum, horum nonnullos 15, quoſdam 13, alios multò plura, alioſque multò pauciora milliaria horæ ſpatio conficere: quoſdam autem tam lento motu ferri, ut vix unum milliare in horâ peragrent. Alii porro Venti ſunt adeo tardigradi, ut eoſdem aliquis, equo vel pedibus iter faciens, facilè prævertat. Quod Senſibus patet; quoties gradum ſiſtimus, lenem auram nos placidè ventilantem percipimus: ſin autem cum eodem pergimus, nullam prorſus ſentimus: ſi vero celeriùs pedem movemus, comitantis & conſpirantis Auræ loco, adverſantem, & in ora vultuſque ſpirantem aerem perſentimus. Ita, quieſcente prorſus Atmoſphærâ, & ſtagnante, ſi fortè ambulamus, aut equitamus, lenem Auram nos tunc prementem ſentimus, tantarum nempe virium, quantæ motui quo ferimur reſpondent. Eodemque Motûs gradu, ſive Velocitate, fertur Venti aura, ſive Aeris fluxus, cum pari impetu nos morantes aut ceſſantes premat.

Ex hiſce Obſervationibus circa *Velocitatem Ventorum*, plurima haud inutilia notare licet. Speciatim verè rationem unam aſſignare, quare *Mercurius* tam diu aſcendit & deſcendit, priuſquam Sudum Cœlum, vel Pluvia inſequitur.

Hæc autem tanquam à propoſito aliena omittam; ſolumque hoc unum quoad Sonos obſervabo: nempe, cum eorum Motus Vento celerior ſit, patet quod iſtæ Atmoſphæræ partes quibus imprimuntur, aut deferuntur Soni, non ſunt eædem ac illæ ex quibus conflantur Venti, ſed quædam aliæ magis æthereæ & volatiles, quantum divinare licet. *Venti* enim celerrimi haud plus quam 60 milliaria Horæ ſpatio prætervolant: *Soni* vero plus quam 700 millia paſſuum eodem tempore percurrunt.

Sin autem objiciatur quod, Venti Sonos celeriores aut tardiores reddunt: Reſponderetur; Hoc non à ſolo proprioque ventoſarum particularum fluxu, ſeu tendentiâ proficiſci, ſed potius ab omnium Atmoſphæræ particularum, cum craſſiorum, tum ætherearum conjuncto & conſpirante motu. Quæ Cursûs, ſive Motûs directio, ſi Sonorum Undulationibus faveat, Sonorum appulſum exinde accelerari; ſin adverſetur, retardari, omninò veriſimile eſt.

Of the Velocity *of* Sounds.

13. Ex dictis proinde, aliiſque quamplurimis quæ prænotavimus, firmiſſimè concludo, Sonos hoc Velocitatis gradu propagari. Nempe, *ad Milliaris intervallum (ſive 5280 Pedum Anglicanorum) ſpatio 9 $\frac{1}{4}$ Semiſecundorum percurrere:* Vel (quod eodem redit) Pedes 571 unius Semiſecundi, vel 1142 Pedes unius Secundi Minuti Temporis ſpatio.

Hoc autem prædictum ſpatium pertranſeunt Soni, ſi tranſverſus Atmoſphæræ fluxus intercurreret, & eſt *Medius* eorum *Progreſſus* ſive *Motus*. Sin autem Ventus Soni rapiditatem augeat, poſſibile eſt ut pluſquam 600 Pedes Semi-ſecundi ſpatio prætereat. Vel è contra, ſi moram

ram ei innectat, haud plus quam 560 Pedes eodem temporis intervallo progrediatur.

Prædictæ Obſervationes, & Experimenta non parum conducere videntur,

Philoſopho, ad *Sonorum* Phænomena abſtruſa explicanda.

Nautæ, qui hinc diſcat quanto intervallo abſunt Naves, quas procul fluctuantes, vel ad anchoras ſtantes cernit: quàm longè item Tellus, eminùs conſpecta, diſtat. Quæ ex Sclopetis de induſtriâ exploſis, ſigno quodam dato, facilè certóque innoteſcant.

Militi, ad inveniendum quam procul Hoſtis Caſtra locavit, ad quam diſtantiam ſita eſt Urbis obſeſſa, &c. ad Tormenta muralia libranda, & dirigendos Pyrobolos, glandeſque ignivomas.

Geographo, ad Locorum diſtantias faciliùs & certiùs menſurandas. Quivis enim intra horam unam aut alteram, totam fere Regionem Tabulâ accuratiſſimè deſcriptam hoc pacto exhibeat. Sclopeta enim diſploſa Diſtantias oſtendent: & quodvis Inſtrumentum Mathematicum quo metiuntur Angulos, vel Inſtrumentum illud vulgare quo Decempedatores utuntur (*the Plain Table* vocatum) vel ſola Regula Pinacidiis inſtructa, variorum locorum Situs indicabit; quæ deinde delineare haud difficile eſt.

Hæc demum obſervandi ratio, Locorum inacceſſorum, præſertim verò latiſſimorum Fluviorum, & ejuſmodi locorum haud aliter menſurabilium, diſtantiis dimetiendis magnopere inſerviat.

Echometræ: De hoc ludicro & jucundo Soni Phænomeno (ſcil. *Echo*) licèt plurimi docti viri olim & poſtea ſollicitè quæſiverint, de plurimis tamen ad idem ſpectantibus non bene inter ſe convenit: ſpeciatim de ſpatio Loci ad repetitionem 1, 2, 3 vel plurium Syllabarum neceſſario; vel (quod eodem redit) de ſpatio ab *Echo* peragrato in certo quodam temporis intervallo. *Merſennus* . . . . paſſus ad Vocem Monoſyllabam repetendam concedit; *Blancanus* 24 paſſus (cui aſtipulatur Dr. *Plott*) ſed *Kircherus* aſſerit nihil omnino certi de eo definiri poſſe, quod nempe Ventorum variatio viriumque Soni intenſio & remiſſio, & multa alia immenſam variationem pariunt. *Of the* Motion *of* Echo's.

Rationem autem hujus diſſenſûs reddere haud difficile eſt. Ex plurimis enim cauſis oriri poteſt; ex tarditate nimirum & diverſâ noſtrorum Senſuum diſpoſitione; vel ex variâ Sonorum audibilitate; ex Syllabarum ipſarum gravi vel acuto ſono ſive earundem contractâ vel productâ pronunciatione; vel ex quâlibet aliâ cauſâ temporis intervallum protrahente. Nullus enim dubito (Exempli gratiâ) quin ſi Objectum aliquod Phonocampticum repercutere potuerit omnes Syllabas hujuſce ſequentis carminis, viz.

Vocalis Nymphæ, quæ nec reticere loquenti,

Quod haud valeret repercutere omnes Syllabas ſequentis carminis, quoniam paulò productior eſt ejus pronunciato, Scil.

Corpus

Corpus adhuc Echo, non Vox erat, & tamen uſum.

Et multò minùs repetere valeret aſperas omnes, & productas Syllabas ſequentis hujus carminis, licet numero pauciores, viz.

Arx, tridens, roſtris, ſphinx, præſter, torrida, ſeps, ſtrix.

Verùm à præcedentibus de Soni motu Obſervationibus concludere licet, Quod, uti Soni, ita Ἠχὼι certa & determinata ſpatia in certo quodam præſcriptoque tempore percurrunt. Quod ipſum ab experientiâ ſæpiùs edoctus ſum, ſcilicet, Echo redire in duplo temporis intervallo, quo Vox Primaria Objectum Phonocampticum pertingebat. Exempli gratia: Si Objectum Phonocampticum Stadium diſtaret; Echûs regreſſus in eodem temporis intervallo fuerit, in quo Primarius Sonus duo Stadia percurriſſet, ſi non repercuſſus fuiſſet.

Et hoc in dimetiendis Locorum diſtantiis magno mihi uſui ſæpè fuit. Exempli gratiâ: Cum in *Thameſis* fluvii ripâ ſtarem, Villæ *Woolwich* oppoſitâ, monoſyllabæ Vocis *Echo* à Domibus adverſis repercuſſa fuit in ſex Semiſecundis Minutis temporis. Unde colligo Latitudinem fluvii *Thameſis*, eo loci, à margine unius Ripæ ad marginem alterius, 1712 pedes Anglicanos eſſe, ſive ſupra quadrantem milliaris. Nam ut 9,25 (Semiſecunda) : ad 5280 (pedes in milliari uno) :: Ita 6 (Semiſecunda) : ad 3424,8 pedes. Cujus dimidium eſt 1712,4 pedes.

Denique hoc pacto *Intonantium Nubium Altitudo*, & ipſius *Tonitru*, *Fulguriſque* Diſtantia facilè innoteſcant.

Of the Nature *and* Properties *of* Sound, *by* G. Grandus. n. 319. p. 270.

XI. Comparat doctiſſimus Præſul *Armachanus* ſcientiam auditus cum Theoria viſionis, atque ut hæc in directam, reflexam, & refractam dividitur, ita illam pari ratione trifariam diſtribuit, ut non modo ſonos directos, & reflexos (quod dudum in uſu fuit) ſed & refractos conſideret; quemadmodum autem eximiis inventis opticis, catoptricis, & dioptricis viſionem à majoribus noſtris magnâ jam ex parte perfectam fuiſſe animadvertit, ita compluribus inſtrumentis Acuſticis, Catacuſticis, & Diacuſticis, ſive Phonicis, Cataphonicis, & Diaphonicis (utrovis enim modo denominat) auditum, tam ex objecti, quàm medii, vel organi parte perfici poſſe non dubitat, eòque ſpectantia problemata proponit, quæ tamen in hoc ſcripto, (†) nedum abſque demonſtratione, ſed & abſque determinatione, aut conſtructione ullâ exhibentur. Multa autem ſunt diſcrimina, quibus propagatio Lucis à diffuſione Soni ſecernitur: inter quæ illud palmarium eſt, quod Lux per lineam rectam ſemper exporrigitur, dum ſonus etiam per curvas, & inflexas utcunque ſemitas quaquaverſum ſpargitur, atque, intercepto cujuſvis opaci corporis obice, ſenſibilis redditur.

† Vid. Supra. V. I. C. V. S. XXII.

Et vero hæc ipſa, quæ de Soni diffuſione doctiſſimus Auctor noſter ediſſerit, ejus differentiam à lucis propagatione manifeſtant: docet ſiquidem, ſonum ſecus parietes, aut fornices lævigatiſſimos, ellipticâ, vel cycloidali, potius quam circulari flexurâ donatos, blando quodam, & ex-

& expeditiſſimo lapſu feliciter excurrere, nec non per mollem aquæ ſuperficiem, ſonoris tremoribus, quibus aer criſpatur, obſequentem validiùs promoveri: quæ vereor, ut in luminis propagatione adeo generatim obſerventur; nam de Ellipſi quidem hoc tantùm habemus ex catoptricâ demonſtratum, quod radii lucis ex altero ejus foco D emanantes, & in ellipticam curvam A B C impingentes, inde reflexi in altero foco E colligentur, at ſi ex alio quovis puncto G, præter focos, exeant radii, non omnes amplius in unum punctum coibunt, ſed ita reflectentur, ut curvam cauſticam *f* F *f* contactu ſuo efforment, ſupra cujus convexitatem exiſtentes uno aut altero reflexo radio, non pluribus gaudere poterunt, in ipſâ vero curvâ poſiti aliquot ex maximè vicinis participabunt: at qui intra cavitatem ejuſdem verſabuntur, ab omni reflexorum radiorum illapſu immunes erunt, adeo nullum inde ſibi emolumentum obventurum ſperabunt. Fig. 176.

Cycloidem quod attinet, oſtendit quidem Cl. V. *Joh. Bernoullius* in Actis *Lipſiæ* 1697. Lucis radium, ſi per media tranſiret, quorum raritates in quolibet puncto juxta rationem ſubduplicatam altitudinum variarent, ita continuo flexu refrangendum, ut in curvam cycloidis ſinuaretur: at ſeu reflexione, ſeu directa per idem medium propulſione, quid figura cycloidis ad feliciorem luminis diffuſionem conferret, planè non video; hæc enim curva focis omnino caret, adeò ut in nullo puncto radios recolligere poſſit, ſed in curvas irregulares abeunt radii ab ipſa reflexi, niſi quod ubi ad axem K L paralleli radii P M, Q N in Cycloidem E M K N H inciderent; tunc linea cauſtica per contactum reflexorum radiorum M R, N S, efformata, ex binis cycloidibus E R L, H S L, circulo ſubduplæ diametri generatis, componeretur, radioſque reflexos confertiſſimos circa utriuſque confinium L, ad medium baſis reflectentis cycloidis exhiberet: cæterum tam in his quàm in aliis cauſticis ex qualibet luminoſi puncti radiorumque poſitione reſultantibus, eædem obſervationes locum haberent, quas cauſticis per ellipſin efformatis competere diximus. Fig. 177.

De planâ aquarum ſuperficie nihil eſt quod addam, cùm pateat, lucis radios per illam aut omnino refractos tranſire, aut ordinatâ reflexione in adverſam partem remitti, perindè ac è Cryſtalli ſolidioris ſuperficie, imò ab hâc aliquanto fortius, quàm ab illâ; tantum abeſt, ut per illam facillimè repentes in directum expeditiùs promoveri poſſint, illumque blandum progreſſum obtinere, quem tremoribus harmonicis, per mollem aquarum ſuperficiem, criſpatione ſuâ ipſorum flexui ſe accommodantem ſerpentibus Auctor tribuit: imò & dubitare licet, an lævigatiſſimæ ſpeculorum ſuperficies, perindè, ac luminis, ſic ſoni reflexionibus valdè conducerent, cùm Echo ipſa ſpeluncarum receſſus aſperrimos, magis quàm politos, ac tenui gypſo incruſtatos parietes habitare videatur, ab incultis vallibus, ab anfractuoſis antris, atque è veterum ædificiorum ruderibus frequentiùs reſpondens.

Hæc

Hæc tamen non ideo à me dicta velim, ut quidpiam aut debitæ fidei, aut promeritæ laudis derogem pronunciatis Cl. Auctoris, quem potiùs extimulandum cenſeo ad hanc Sonorum Theoriam ex integro edendam; ut quâ tandem lege ſonori tremores per aerem, per aquam, & per variæ denſitatis corpora quælibet, tum fluida, tum ſolida progrediantur, & in quo ſoni, luciſque convenientia nondum ſatis hactenus nobis comperta, conſiſtat, innoteſcere poſſit; unde firmatis Acuſticæ fundamentis mirum in modum ſcientia hæc deinceps perficeretur, idoneis organis ad ſonum congregandum, augendum, promovendum, multiplicandum, aptiúſque diſcernendum excogitatis; Acuſticum, ſeu ſphæram Phonicam ab eodem propoſitam, divinando magis, quàm interpretando, exponere utcunque aggrediar, verbis illius primum adductis, ut cum meis conjecturis mox ſubjiciendis conferri queant, & quàm exactè iiſdem reſpondeant, cujuſlibet poſſit arbitrio judicari.

Addam hoc loco, inquit Auctor, *Semiplani Acuſtici, ſeu Spheræ Phonicæ figuram, quaſi tentamen ad magnum ſcientiæ hujus principium explicandum, quod in ſonorum progreſſione conſiſtit. Conſideretis oportet rude hoc ſemiplanum velut horizonti parallelum, nam ſi eidem perpendiculare fuerit, ſuppono extremitatem illius ſuperiorem non amplius circularem futuram, ſed hyperbolicam, partem verò inferiorem æqualem fore uni ex maximis terræ circulis: adeo ut univerſa ſphæra Phonica, ſi ita appellare liceat, ſit quædam hyperbola ſolida, ſuper concava baſis ſphæricæ ſuperficie erecta.* Diagramma *Londino*
Fig. 178. tranſmiſſum hujuſmodi erat, nullis præterea notis ad ejus illuſtrationem facientibus inſtructum.

Ipſe igitur, hoc alio Schemate ſubſtituto, mentem Auctoris aperire
Fig. 179. ſatagam. Sit terræ globus C G F E, atque in puncto C ejus ſuperficiei ſonus aliquis excitetur. Hic per terram ipſam nec non per aerem circumquaque propagabitur, adeo ut quo tempore ad maximum terræ circulum polo C deſcriptum, nempe ad Peripheriam G B E aut reipſâ (licèt fortaſſe inſenſibiliter) pervenit, aut ſaltem (ſi validior eſſet) perveniret, per aerem diffuſus, quoddam ſpatium repleret, pro variâ tranſitûs facilitate, non prorſus ſphæricè, ſed inæqualiter exporrectum, & à perimetro hyperbolæ G I. A K E, circa axem C A O ſonoro corpori C perpendicularem poſitæ, circumſcriptum: imò verò à ſuperficie conoidis hyperbolicæ, quam hyperbola A I. G circa ſuum axem rotata generat, definitum. Itaque univerſa ſphæra phonica, per quam dato tempore ſonus extenditur, erit ſolidum ſpatium comprehenſum ab hyperbolicâ conoide G A E B, quæ maximo terræ circulo G B E inſiſtit, & concavâ ſuperficie hemiſphærica G C E B inferiùs terminatur: quod quidem ſpatium plano ad horizontem parallelo ubilibet ſectum, exhibebit ſemicirculum L I K, qualem oſtendit Auctoris figura, quem & ſemiplanum appellat, eo quod ipſius diagrammatis proſpectus alteram ſolùm medietatem ejus exhibeat, dimidiâ reliquâ trans hyperbolam verticalem (quæ & ipſa phonicam ſphæram per axem bifariam ſecat) inconſpicuâ manente. Verùm quæ ſit hujuſmodi hyperbolæ

perbolæ ſpecies, aut quibus principiis doctrina hæc fulciatur, nec Auctor indicat, nec mihi ſuppetit unde hac de re quidpiam certi conjiciam.

Inverſo igitur veſtigandi ordine procedens, detegam primò, per quod linearum genus tremores ſonoros diffundi oporteret, ut in ejuſmodi hyperbolam dato tempore expanderentur ; ſecundò, quæ raritatis variatio foret in variis aeris altitudinibus ſupponenda, ut (ſtante refractionis communi lege, qualem radii lucis obſervant) ſonorum directiones juxta inventam linearum ſpeciem flectere poſſet ; ac tertiò, quæ viciſſim dicenda ſit lex refractionis, quam ſonori tremores in ejuſmodi curvarum genus abeuntes ſequuntur, ſuppoſitâ raritatis aeris variatione tali, qualem plerique Philoſophorum, & Mathematicorum in illo agnoſcunt juxta reciprocam rationem ponderis atmoſphæræ incumbentis, & inferiores partes gravantis, quam experimentis congruere teſtantur.

Pro quo conſideremus, corpus ſonorum C tremores ſuos per directiones C *n*, C *m*, C *h*, quaquaverſus communicare, aut certè juxta eas lineas, per quas impulſum fuerat, ſe reſtituendo repellere aerem, eumdemque frequentiſſimis oſcillationibus protrudere, quibus criſpatur, atque ad motum tremulum juxta eaſdem directiones diffuſum ſollicitatur ; hi ergo tremores quodam minimo tempore perveniſſe concipiantur ad puncta *n*, *m*, *h*, unde iter ſuum proſequentes, ſucceſſivè poſt aliud datum tempus ſimul propagabuntur, primus ad punctum N, ſecundus ad M, tertius ad H ; iterumque poſt aliud datum tempus ſimul progredientur, prior ad G, alter ad L, poſtremus ad A. Nunc igitur lineas quidem C *n* N G, C *m* M L, C *h* H A, per quas quilibet tremor ſucceſſivè diffunditur, voco *Radios ſonoros* ; lineas vero *n*, *m*, *h*, N M H, G L A, quas prædicti ſonori radii, omneſque alii ſynchroni iis intermedii dato quolibet tempore ſimul attingunt, *Undas ſonoras* appello. Fig. 180.

Et quidem in medio prorſus ubilibet uniformi, ceſſante causâ, quæ tremores ſonoros a ſuâ directione in hanc vel illam partem deflectere cogat, patet ſonoros radios ſemper rectos procedere, ſeu per viam breviſſimam ab uno ad alium terminum directè progredi, atque undas penitus circulares ſonoro corpori concentricas efficere ; quia cum non majorem hic, quam alibi tranſitus difficultatem inveniant, utique ad pares diſtantias ſinguli dato quovis tempore elongabuntur : Secabit autem radius quilibet undam ſuam perpendiculariter, atque undæ quælibet concentricæ & ſimiles erunt, ut conſtat ex elementis.

At in medio difformis denſitatis, velut in aere terræ circumfuſo, qui diverſam pro variâ altitudine (nam caloris, frigoris, humiditatis, & ſiccitatis vices, quæ ad certam legem revocari non poſſunt, pro nunc ſeponimus) raritatem obtinet, ſolus radius C H A perpendiculariter trajiciens omnes aereas lamellas, ſive ſuperficies terræ concentricas, irrefractus tranſibit, ac rectus manebit ; cæteri vero iiſdem ſuperficiebus obliquè impingentes continuo quodam flexu in quolibet puncto

refringentur, & in curvas C *m* M L, C *n* N G ſinuabuntur; nec non pro variâ tranſitus facilitate non ad eandem ubivis diſtantiam dato tempore progredientur; quare puncta A, L, G, aut H, M, N, quæ eodem momento ſonus per quoſlibet radios emiſſus attingit, inæqualiter à ſonoro C remota erunt, adeòque unde A L G, H M N, *h m n*, omnino circuli non erunt corpori ſonoro concentrici, ſed alterius generis curvæ, quas tamen oportet invicem ſimiles eſſe, ac ſimiliter poſitas: quare in hypotheſi noſtri Auctoris, qui extremam illam undam A L G, ultimos globi terraquei fines lambentem hyperbolicam voluit, neceſſe eſt quaſvis alias undas intermedias H M N, *h m n*, eſſe hyperbolas ſimiles, ac ſimiliter poſitas diverſis quidem verticibus A, H, *h*, ſed eodem centro, ad eundem axem, & ſub ſimilibus laterum figuris deſcriptas; nam quæcumque ſit ratio, quæ oſtendat, ob ſimultaneum appulſum ſoni ad puncta, A, L, G, per vias ſynchronas C H A, C M L, C N G, undam A L G faceſcere in curvam talis ſpeciei (puta hyperbolicam): eadem prorſus iiſdem fundamentis evincet, ob ſimultaneum appulſum ſoni etiam ad puncta, H, M, N, per ſynchronas lineas C *h* H, C *m* M, C *n* N, undam H M N, in curvam ejuſdem ſpeciei (nempe hoc caſu in hyperbolam ſimilem, ac ſimiliter poſitam) pariter abire, ut de ſe conſtat. Nec dubium inſuper, ſonoros radios C H A, C M L, C N G, ſemper undas illas ſimiles A L G, H M N, *h m n* debere perpendiculariter, ſive ad rectos angulos ſecare, ut in circularibus undis contingit; quod cùm in ſimili propoſito de lucidis undis oſtenderit Vir Cl. Chriſtianus Hugenius, pag. 44. tractatus ſui de Lumine Gallicè editi, non eſt cur in hac obſervatione pluribus momentis confirmandâ tempus teratur.

Itaque inveſtigatio viæ, per quam radii ſonori, juxta hypotheſin Auctoris propagantur, ad hoc purè Geometricum Problema reducitur, ut inquiratur natura curvarum, quaſlibet hyperbolas ſimiles, & circa eundem axem, eodem centro ſimiliter deſcriptas, perpendiculariter ſecantium. Fig. 181. Sint hyperbolæ ſimiles A L G, H M N, *h m n*, aliæque innumeræ intermediæ, aut ſupra, vel infra ipſas ſimiliter poſitæ, idem commune centrum O habentes, eodemque axe O A H, cui alter O S conjugatur, deſcriptæ: ducenda eſt per punctum C curva C *m* M L, aut C *n* N G, propoſitas omnes hyperbolas perpendiculariter ſecans. Deſcribatur per datum punctum C, inter aſymptotos O A, O S hyperbola C *m* M L talis naturæ, ut poſitâ ratione tranſverſi lateris priorum hyperbolarum A L, H M, &c. ad latus rectum earundem æquali rationi *t* ad *r*, poteſtates ordinatarum L Q denominatæ ab exponente *r* ſint reciprocè proportionales poteſtatibus abſciſſarum à centro O Q denominatis ab exponente *t*, nempe facta O Q = *x*, & Q L = *y*, ita ut $y^r = \frac{1}{x^t}$; ſive, ducta qualibet alia ordinata *m i*, M I, ita ut ratio diſtantiarum à centro O Q, O I ſit reciprocè tam multiplicata rationis

applicatarum I M, Q L, quam multiplex eſt fractio $\frac{r}{t}$ unitatis. Dico hanc ſatisfacere quæſito; ducta enim cujuſvis hyperbolæ A L tangente L P in puncto, ubi à curva C M L ſecatur; nec non S L R tangente ipſius hyperbolæ C M L in eodem puncto, patet ex his quæ in Theorematum Hugenianorum demonſtratione, cap. 7. n. 9. oſtendimus, fore O Q ad Q R, ut exponens poteſtatis diſtantiarum O Q ad exponentem poteſtatis ordinatarum Q L, nempe ut *t* ad *r*; ſed ut *t* ad *r*, nempe tranſverſum latus ad rectum, ita per 37. l. Conic. eſt rectangulum O Q P ad Quadratum Q L; igitur ut O Q ad Q R, ſive ſumptâ communi altitudine Q P, ut rectangulum O Q P ad rectangulum P Q R, ita rectangulum O Q P ad quadratum Q L, quod ideo æquabitur rectangulo P Q R; quare angulus P L R rectus erit: unde curva C M L perpendiculariter occurret in puncto L hyperbolæ A L G, eodemque modo aliis hyperbolis H M N, *h m n*, in punctis M, *m*, in quibus illas ſecat, perpendicularis eſſe oſtendetur; quod erat, &c.

Hinc primò colligitur, quòd ſi hyperbola determinans ſphæram Phonicam Auctoris nempe A L G, aliæque ſimiles concentricæ H M N, *h m n*, fuerint æquilateræ, tunc propter æqualitatem laterum *t* & *r*, hyperbola C M L erit & ipſa hyperbola *Apolloniana*, & quidem pariter æquilatera; ejus enim æquatio ſuperiùs allata transformabitur in hanc $y = \frac{1}{x}$ ubi ratio ordinatarum ſimpliciter reciproca erit rationis diſtantiarum à centro; itaque radii pariter ſonori æquè ac ſonoræ undæ juxta hanc hypotheſin forent hyperbolæ ejuſdem ſpeciei, diversâ duntaxat poſitione collocatæ: Memini porro *Newtonum* Opticæ ſuæ, lib. 3. p. 287. Obſerv. 10. oſtendere, radios lucis trans duorum cultrorum acies in obſcurum cubiculum admiſſos, in hyperbolicas fimbrias, qualis eſſet C M L, pariter ſinuari, cujus phænomeni ſi ratio phyſica afferri poſſet, eadem hyperbolicos pariter ſoni radios, quales Armachani Præſulis ſyſtema invehere videtur, fortaſſe perſuaderet.

Secundò obſervandum eſt, quòd ſi plures ejuſmodi curvæ, ſeu radii hyperbolici *m* M L, *n* N G, &c. ſecantes undas hyperbolicas A L G, H M N, &c. perpendiculariter deſcribantur, non in unum exactè punctum C poterunt convenire, tametſi propius & propiùs coëant ad partes C, atque ad intervallum pervenire poſſint, minus quolibet dato intervallo; quare concipiendi erunt radii illi hyperbolici à corpuſculo C alicujus extenſionis procedere, non ab aliquo mathematico puncto, quod ipſum convenientiſſimum eſt; ſonus enim ex colliſione corporum naſcitur, non ex unius rigoroſi puncti ſeu termini extenſionis tremore produci poteſt.

Imò cum omnes undæ à ſonoro corpore propagatæ eſſe debeant, ut ſupra vidimus, hyperbolæ ſimiles; congruum eſt, ut concipiamus, corpus ſonorum C quaſi fibrillam minutiſſimam frequentiſſimè oſcillantem, cujus minima, & veluti initialis unda infinitè propemodùm exigua 2 3 4, & ipſa reverà hyperbolica ſit, ſeu potius apex phyſicus alicujus hyperbolæ; ita ut nimirum fibrilla oſcillatoria corporis ſonori C, dum pulſatur, ex ſitu directo 2 C 4 detruſa in ſitum concavum 2 5 4, vi percuſſionis adigatur, tum vehementiſſimi elateris ſui nec non propriæ tenſionis vi, reſtituta in convexam hyperbolam 2 3 4 intumeſcat, ac rurſus reducta alternis vibrationibus fluctuans hinc inde ſuos tremores in hyperbolicas undas, ipſimet initialibus 2 3 4, 2 5 4 perpetuò ſimiles, ſurſum, ac deorſum ſuapte naturâ, & in medio utrinque libero expandat, ſed obice terreſtris globi C E (cujus centrum T) impedita fortaſſe, hyperbolicas undas ſuas dumtaxat ſurſum propaget, & Phonicam Sphæram ab Auctore noſtro excogitatam deſcribat, hemiſphærio terreſtri ab inferiori parte interruptam, ac definitam. Quod ſi vera eſſet P. *Pardies* doctrina, Artic. 81. ſuæ ſtaticæ propoſita, quod chordæ extenſæ reipſâ hyperbolicam figuram, qualis eſſet 2 5 4, cujus centrum ſit idem quod centrum terræ, vi proprii ponderis aſſumant, nemo non videt eam ipſam confirmando Auctoris noſtri ſyſtemati fore congruentiſſimam; hinc enim ratio haberetur, cur fibrilla quævis ſonori corporis C, dum ad vibrationes harmonicas ſollicitatur, in hyperbolam 2 5 4 excurreret centrum habens in centro terræ T, ſimiliterque in aliam æqualem 2 3 4 aſſurgeret, indeque per alias ampliores hyperbolas tremorem diffunderet, quarum omnium centrum eſſet O æquè diſtans à ſonoro corpore C, ac ſonorum corpus illud remotum ſit ab ipſomet centro terræ; quare diſtantia C O, æqualis ſemidiametro Globi Terraquei limitem definiret, ultra quam nulla ſonora unda propagaretur, nulluſque poſſet ſonus audiri, & linea O S, utpotè aſymptotus quorumvis hyperbolicorum radiorum, per quos defertur ſonus, confinium beatæ illius regionis conſtitueret, in quâ ab omni terrenarum rerum ſtrepitu ſecuris in ſummâ tranquillitate philoſophari liceret.

Porro ne quis ſpeculationem hanc eo nomine contemnendam putet, quòd fibrilla quævis ſonori corporis, cùm breviſſima ſit, ac validè diſtenta, ſemper in ſitu recto 2 C 4 manere videatur, nec poſſe in concavas, aut convexas hyperbolas 2 5 4, 2 3 4 ſinuari, conſiderandum inſuper eſt, hyperbolas quò majoribus axibus præditæ fuerint, eò magis ampliari, & ad lineam rectam accedere; itaque ob ingentem diſtantiam centrorum T, vel O, ſicut lineæ quas gravia cadentia deſcribunt, licet in centrum T collimantes pro parallelis habentur, & arcus circuli horizontalis cum rectâ ejus tangente confunditur, ita & initiales illas hyperbolas 2 5 4, 2 3 4 fermè coincidere dicendæ ſunt cum rectâ 2 C 4, unde ſenſibilis non eſt incurvatio fibrillarum oſcillantium in ſonoro corpore, nec ſe prodit undarum hyperbolicarum ſpecies, niſi ubi in amplius ſpatium G L A L G dilatatæ fuerint, centro ſuo propiùs accedentes.

Ani-

Animadvertendum adhuc tamen, his principiis positis, consequens fore, ut sonus hinc inde ad latera non excurrat ultra spatium ab hyperbolicis extremis radiis 2 9 8 *g*, 4 7 6 *g* comprehensum, quas tangerent rectè T 2, T 4, à centro terræ per terminos fibræ oscillantis adductæ; ac reverà fibræ illius tremores juxta aliam directionem non procederent, quam per T 2, T 3, T 4, aliasque intermedias angulo 2 T 4 comprehensas singulis particulis fibræ ejusdem correspondentes; itaque spatium extra dictas hyperbolas 2 9 8 *g*, 4 7 6 *g* positum ab omni tremore harmonico vacaret, nec posset juxta sensum Auctoris phonica sphæra ad integrum terræ hemisphærium exporrigi; itaque oportet, nunquam reipsâ unicam aliquam sonori corporis fibrillam tremere, quin terminos aliarum fibrarum, quibus connectitur, & inter quos distenditur, eo ipso trahat, & ad harmonicum tremorem pariter sollicitet; quæ rursus alias, quibus implicantur, abducunt, & ad tremorem exstimulant, quemadmodum tensa chorda musica ligneo instrumento, cui alligatur, tremores suos evidenter communicat; itaque harmonicæ oscillationes in alia corpora, quibus mediatè vel immediatè connectitur, percussâ fibra sonori corporis, subindè transfunduntur, licet magis magisque semper debilitatæ, ac demum insensibiles redditæ per hemisphærii terrestris superficiem sparguntur, & longiùs ac longiùs serpentes obrepunt (quod auris ipsa terræ applicata, & magnos saltem fragores in maximâ distantiâ excitatos, discernens testari potest) itaque ex aliis etiam locis emergunt alii sonori radii hyperbolici per totum terræ hæmisphærium, à quibus Phonica sphæra Præsulis Armachani satis impleri possit.

Brevior ero in duobus reliquis problematibus, à me supra propositis, prosequendis; conabor autem secundam quæstionem generalius solvere, ut major inde fructus elici queat; intelligatur quivis radius seu lucidus, seu sonorus N *n* G, in cujusvis naturæ curvam, continuâ sui refractione, mutatus: quæritur qua lege variari supponenda sit densitas, aut raritas medii in ejus diversis altitudinibus, ut stante refractionis theoriâ, quæ sinum refractionis semper raritati medii refringentis proportionalem supponit, radius ille in talis naturæ curvam obire potuerit? Sit axis curvæ N *n* G, quam radius refractus efficit, recta C O, Fig. 182. in qua sumpto quolibet puncto C, radio quovis C L describatur quadrans circularis L P *p*, ductaque ubilibet refracti radii tangente N R, *n r*, agatur ex C radius dictæ tangenti parallelus, occurrens circulo in P, ductaque P F axi parallela occurrat ordinatæ N Q ad axim perpendiculari in puncto F; dico inde ortam curvam F *f* F exprimere suis ordinatis F Q, *f q* raritates medii in variis ejus altitudinibus; nam quia C P est parallela ipsi R N, erit angulus P C B æqualis angulo, quem radius refractus N *n* in puncto N efficit cum perpendiculo; & ideo B P, sive F Q erit semper sinus refractionis, posito C P sinu toto; quare cum suppositâ sit lex ea refractionis, ut sinus ejusdem proportionalis sit raritati medii; utique eadem F Q exprimet medii raritatem ad altitudinem Q, sive ad æquè altum punctum N, per quod radius transit. Quod erat, &c.

In

In noſtro autem propoſito, ubi $QN = \frac{1}{X^{\frac{t}{r}}}$ propter $Y^{r} = \frac{1}{X^{t}}$, ſi FQ exponens raritatem aeris vocetur Z, erit $Z = \sqrt[t]{X^{2r+2t}} + tt$;

aut ſumpta etiam r, & CP pro unitate, fiet $Z = \sqrt[t]{X^{2+2t}} + tt$, atque in caſu, quòd unda hyperbolica fuerit æquilatera, adeoque & radius hyperbola ſimilis æquilatera, $y = \frac{l}{X}$ propter $t = 1$, fiet

$$Z = \frac{1}{\sqrt{X^4 + 1}}.$$

Quoniam vero tum *Jacobus Hermannus* in Actis *Lipſiæ* 1706, tum *David Gregorius* Aſtronom. lib. 5. oſtendunt Curvam, quæ determinat gradus raritatum aeris, eſſe logarithmicam, adeo ut altitudines OQ, oq, ſive X ſint logarithmi numerorum exponentium aeris raritates in punctis Q, q: patet radii continuè refracti Nn, NG curvaturam ea lege procedere, ut ſinus complementi incidentiæ, & refractionis ad poteſtatem $\frac{r}{r+t}$ elevati rationem habeant compoſitam ex ratione ſinuum rectorum ad ſimilem poteſtatem evectorum, & ex ratione quam habent logarithmi raritatum.

Cæterum etſi conſenſerim, ordinariam legem refractionis lucis dare ſinus incidentiæ & refractionis, proportionales raritatibus mediorum, non diſſimulo tamen id fortaſſè non adeo exactum eſſe, cum ratio ſinuum in refractione ex aere in vitrum ſit circiter ſeſquialtera, aer verò pluſquàm millies vitro ſit rarior; ſed cum viderent Geometræ majorem fieri ſinum refractionis in tranſitu ad aliud medium pro majore facilitate quâ illud lux penetrat in communi hypotheſi, vel pro majori difficultate juxta Carteſium, qui ſupponit è contrario lucem magis refringi ob majorem difficultatem in rariori medio quàm in denſiori (ut gravia corpora ob majorem difficultatem penetrandi denſiora corpora in his magis refringuntur, reſiliendo à perpendiculari) & utramque legem in eo convenire, quod pro majori medii raritate, major fieret refractio: hinc invaluit, ut ſinus proportionales dicerentur, non quidem facilitati, aut difficultati tranſitus, quarum alterutra ab aliis in dubium vocatur, ſed raritati medii, in quâ omnes conveniunt, licet vera proportio illi non prorſus reſpondeat in eadem geometricâ ratione; itaque ubicunque rari-

raritatis mentio facta eſt, ſubroganda eſt fortaſſe facilitas tranſitus in communi, & difficultas in Carteſiana hypotheſi, præterquam ubi diximus, raritatem ex pondere aeris incumbentis variatam reſpondere altitudinibus, ut numeri logarithmis ſuis reſpondent; hoc enim exactè veriſſimum eſt.

XII. *A Paper omitted.*

Theoremata quædam *Infinitam Materiæ Diviſibilitatem* ſpectantia, quæ ejuſdem raritatem & tenuem compoſitionem demonſtrant, quorum ope plurimæ in Phyſica tolluntur difficultates. A *Johanne Keill*, M. D. Profeſ. Aſtron. *Savil. Oxon.* & S R S. n. 339. p. 82.

CHAP. V.

Hydroſtatics. Hydraulics.

I. THE following Experiment ſeems to be of uſe in diſcovering the Proportions of the Attractions of Fluids; I ſhall give what Account I can of it, though I have not here Conveniencies to make it in ſo ſucceſsful a Manner as I could wiſh. *Aſcent of Water between two Glaſs-Planes, by Dr. B. Taylor.* n. 336. p. 538. *June* 25. 1712.

I faſtened two Pieces of Glaſs together, as flat as I could get; ſo that they were inclined in an Angle of about two Degrees and a half, then I ſet them in Water with the contiguous Edges perpendicular. The upper Part of the Water, by riſing between them made this *Hyperbola*, *Fig.* 183. which is as I copied it from the Glaſs. Fig. 183.

I have examin'd it, as well as I can, and it ſeems to approach very near to the common *Hyperbola*. But my Apparatus was not nice enough to diſcover this exactly.

The perpendicular *Aſymptote* was exactly determin'd by the Edge of the Glaſs; but the *Horizontal* one I could not ſo well diſcover.

II. Some Days ago a Method propoſed to me by an ingenious Friend for making a perpetual Motion, which ſeem'd plauſible, and eaſily demonſtrable from an Obſervation of the late Mr. *Hawkſbee*, ſaid to be grounded upon Experiment, was tried; which (though not ſucceeding) has given Occaſion not only to rectify ſome Miſtakes, into which we we had been led by the late Mr. *Hawkſbee*, but likewiſe to detect the real Principle, by which Water is rais'd and ſuſpended in Capillary Tubes above the Level. *The* Cauſe *of the* Aſcent *and* Suſpenſion *of* Water *in* Capillary Tubes, *by Dr.* J. Jurin. n. 355. p. 739.

My

Fig. 184. *My Friend's Propoſal was as follows.*] Let *A B C* be a capillary Siphon, compos'd of two Legs, *A B*, *B C*, unequal both in Length and Diameter; whoſe longer and narrower Leg *A B* having its Orifice *A* immerſt in Water, the Water will riſe above the Level, till it fills the whole Tube *A B*, and will then continue ſuſpended. If the wider and ſhorter Leg *B C*, be in like manner immerſt, the Water will only riſe to ſome Height, as *F C*, leſs than the entire Height of the Tube *B C*.

This Siphon being fill'd with Water, and the Orifice *A* ſunk below the Surface of the Water *D E*, my Friend reaſons thus:

Since the two Columns of Water *A B* and *F C*, by the Suppoſition, will be ſuſpended by ſome Power acting within the Tubes they are contain'd in, they cannot determine the Water to move one Way, or the other. But the Column *B F*, having nothing to ſupport it, muſt deſcend, and cauſe the Water to run out at *C*. Then the preſſure of the Atmoſphere driving the Water upward through the Orifice *A*, to ſupply the Vacuity, which would otherwiſe be left in the upper Part of the Tube *B C*, this muſt neceſſarily produce a perpetual Motion, ſince the Water runs into the ſame Veſſel, out of which it riſes. But the Fallacy of this Reaſoning appears upon making the Experiments.

Exp. 1. For the Water, inſtead of running out at the Orifice *C*, riſes upwards towards *F*, and running all out of the Leg *B C*, remains ſuſpended in the other Leg, to the Height *A B*.

Exp. 2. The ſame thing ſucceeds upon taking the Siphon out of the Water, into which its lower Orifice *A* had been immerſt, the Water then falling in Drops out of the Orifice *A*, and ſtanding at laſt at the Height *A B*. But in making theſe two Experiments, it is neceſſary that *A G*, the Difference of the Legs, exceed *F C*, otherwiſe the Water will not run either Way.

Exp. 3. Upon inverting the Siphon full of Water, it continues without Motion either Way.

The Reaſon of all which, will plainly appear, when we come to diſcover the Principle by which the Water is ſuſpended in capillary Tubes.

Mr. *Hawkſbee*'s Obſervation, is as follows.

Fig. 185. Let *A B F C* be a capillary Siphon, into which the Water will riſe above the Level, to the Height *C F*, and let *B A* be the Depth of the Orifice of its longer Leg below the Surface of the Water *D E*. Then the Siphon being fill'd with Water, if *B A* be not greater than *C F*, the Water will not run out at *A*, but will remain ſuſpended.

This ſeems indeed very plauſible at firſt Sight. For ſince the Column of Water *F C* will be ſuſpended by ſome Power within the Tube, why ſhould not the Column *B A* being equal to, or leſs than the former, continue ſuſpended by the ſame Power?

Exp. 4.

Fig. 170

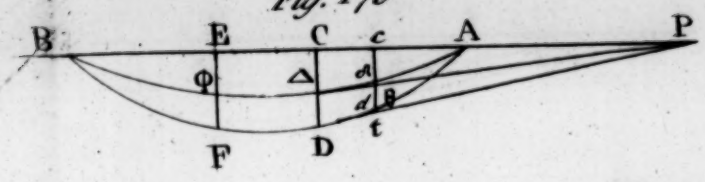


Fig. 171

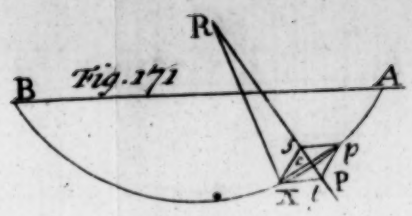


Fig. 173

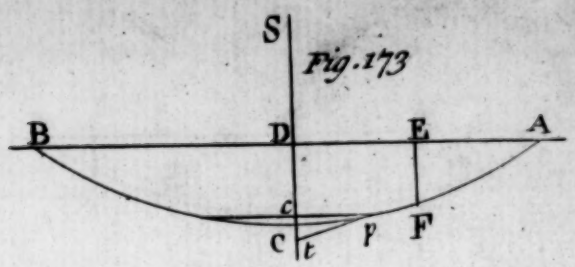


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Fig. 175

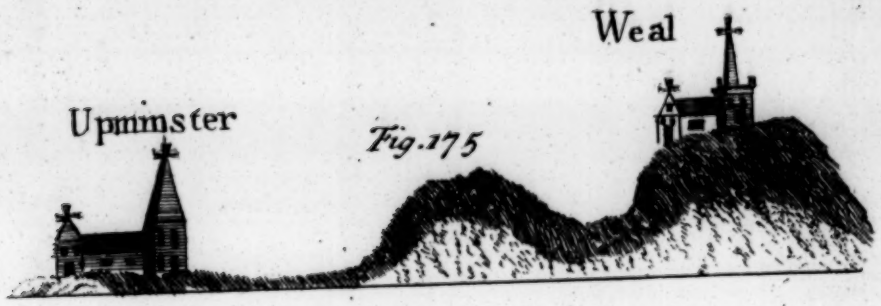


Fig. 172

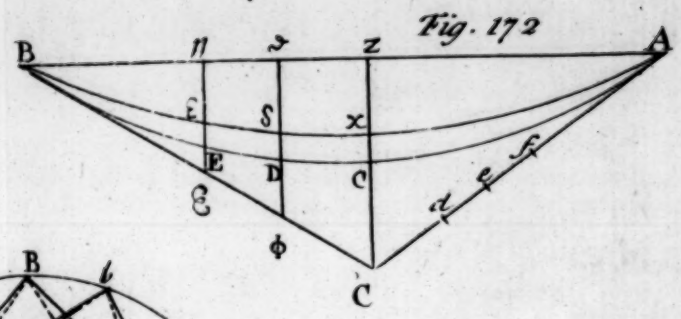


Fig. 174

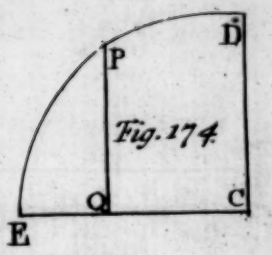


Fig. 177

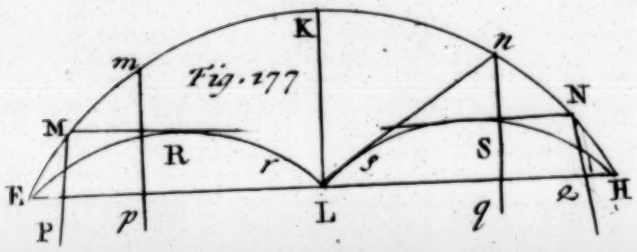


Fig. 176

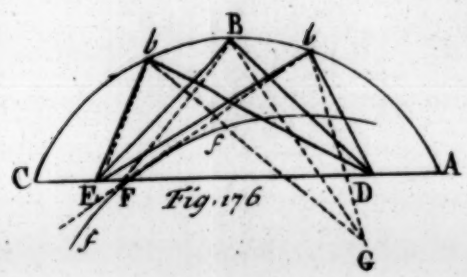


Fig. 179

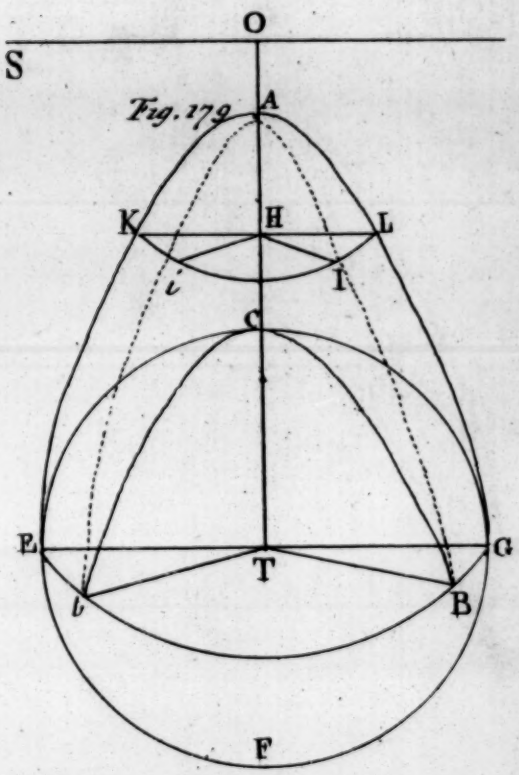


Fig. 180

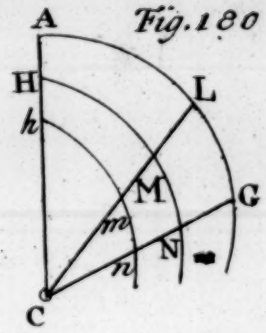


Fig. 181

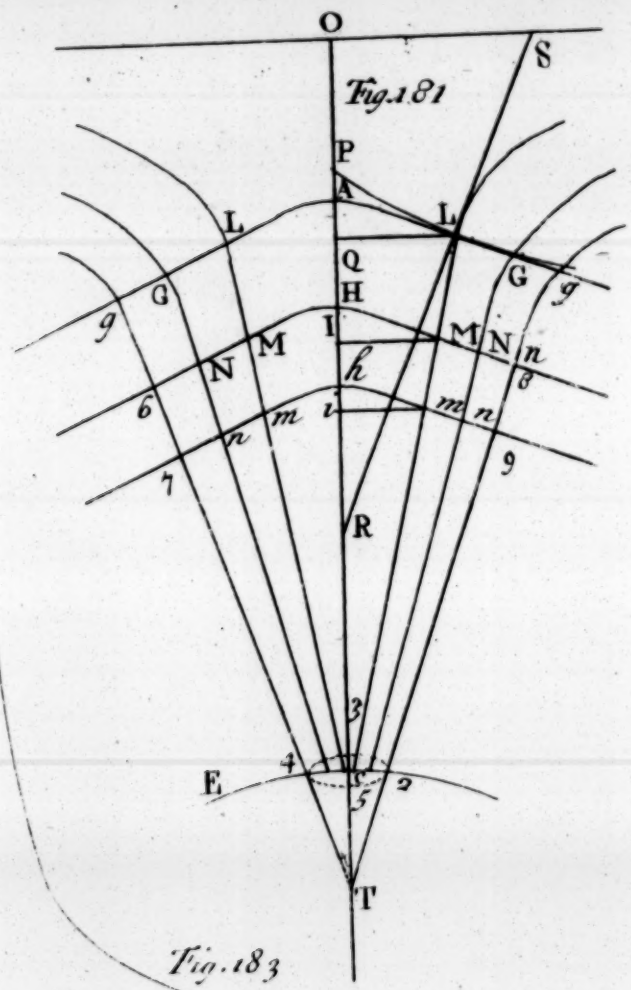


Fig. 183

Fig. 182

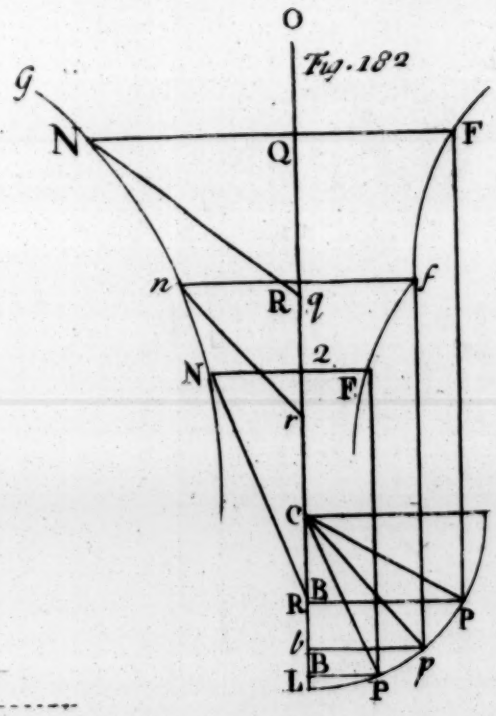
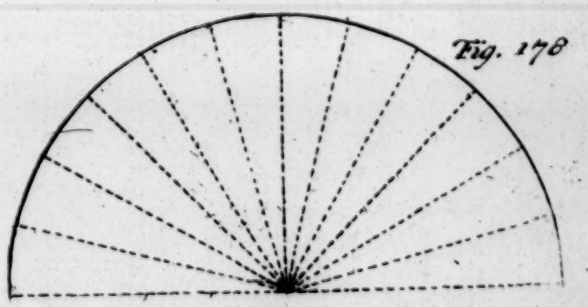


Fig. 178



Exp. 4. In fact, if the Orifice *C* be lifted up out of the Water *D E*, the Water in the Tube will continue ſuſpended, unleſs *B A* exceed *F C*.

Exp. 5. But when *C* is never ſo little immers'd in the Water, immediately the Water in the Tube runs out in Drops at the Orifice *A*, tho' the Length *A B* be conſiderably leſs than the Height *C F*.

Mr. *Hawkſbee*, in his Book of Experiments, has advanced another Obſervation, namely, that the ſhorter Leg of a Capillary Siphon, as *A B F C*, muſt be immers'd in the Water to the Depth *F C*, which is equal to the Height of the Column, that would be ſuſpended in it, before the Water will run out at the longer Leg.

Exp. 6. From what Miſtake this has proceeded, I cannot imagine; for the Water runs out at the longer Leg, as ſoon as the Orifice of the ſhorter Leg comes to touch the Surface of the ſtagnant Water, without being at all immers'd therein.

I proceed now to enquire into the Cauſe of the Aſcent and Suſpenſion of Water in capillary Tubes.

That this Phænomenon is no Way owing to the Preſſure of the Atmoſphere, has been, I think, ſufficiently prov'd by Mr. *Hawkſbee*'s Experiments.

And that the Cauſe aſſign'd by the ſame Perſon, namely, the Attraction of the concave Surface, in which the ſuſpended Liquor is contain'd, is likewiſe inſufficient for producing this Effect, I thus demonſtrate.

Since in every capillary Tube the Height, to which the Water will ſpontaneouſly aſcend, is reciprocally as the Diameter of the Tube, it follows, that the Surface containing the ſuſpended Water in every Tube is always a given Quantity: but the Column of Water ſuſpended is, as the Diameter of the Tube. Therefore, if the Attraction of the containing Surface be the Cauſe of the Water's Suſpenſion; it will follow, that equal Cauſes produce unequal Effects, which is abſurd.

To this it may perhaps be objected, that, in two Tubes of unequal Diameters, the Circumſtances are different, and therefore the two Cauſes, tho' they be equal in themſelves, may produce Effects that are unequal. For the leſſer Tube has not only a greater Curvature, but thoſe Parts of the Water, which lie in the middle of the Tube, are nearer to the attracting Surface, than in the wider. But from this, if any thing follows, it muſt be, that the narrower Tube will ſuſpend the greater Quantity of Water, which is contrary to Experiment. For the Columns ſuſpended are as the Diameters of the Tubes.

But as Experiments are generally more ſatisfactory in Things of this Nature, than Mathematical Reaſonings, it may not be amiſs to make uſe of the following, which appear to me to contain an *Experimentum Crucis*.

The Tube *C D* is compoſed of two Parts, in the wider of which the Water will riſe ſpontaneouſly to the Height *B F*, but the narrower Fig. 186.

Part, if it were of a ſufficient Length, would raiſe the Water to a Height equal to *C D*.

Exp. 7. This Tube being fill'd with Water, and the wider End *C* immers'd in the ſtagnant Water *A B*, the whole continues ſuſpended.

Exp. 8. The narrower End being immers'd, the Water immediately
Fig. 187. ſubſides, and ſtands at laſt at the Height *D G* equal to *B F*.

From which it is manifeſt, that the Suſpenſion of the Water in the former of theſe Experiments is not owing to the Attraction of the containing Surface: ſince, if that were true, this Surface being the ſame, when the Tube is inverted, would ſuſpend the Water at the ſame Height.

Having ſhewn the Inſufficiency of this Hypotheſis, I come now to the real Cauſe of that Phænomenon, which is the Attraction of the Periphery, or Section of the Surface of the Tube, to which the upper Surface of the Water is contiguous and coheres.

For this is the only Part of the Tube, from which the Water muſt recede upon its ſubſiding, and conſequently the only one, which by the Force of its Coheſion or Attraction, oppoſes the Deſcent of the Water.

This likewiſe is a Cauſe proportionable to the Effect which it produces; ſince that Periphery, and the Column ſuſpended, are both in the ſame Proportion as the Diameter of the Tube.

Tho' from either of theſe Particulars it were eaſy to draw a juſt Demonſtration, yet to put the Matter out of all Doubt, it may be proper to confirm this Aſſertion, as we have done the former, by actual Experiment.

Fig. 188. Let therefore *E D C* be a Tube, like that made uſe of in the 7th and 8th Experiments, except that the narrower Part is of a greater Length; and let *A F* and *B G* be the Heights, to which the Water would ſpontaneouſly riſe in the two Tubes *E D* and *D C*.

Exp. 9. If this Tube have its wider Orifice *C* immers'd into the Water *A B*, and be fill'd to any Height leſs than the Length of the wider Part, the Water will immediately ſubſide to a Level with the Point *G*; but if the Surface of the contain'd Water enter never ſo little within the ſmaller Tube *E D*, the whole Column *D C* will be ſuſpended, provided the Length of that Column do not exceed the Height *A F*.

In this Experiment it is plain, that there is nothing to ſuſtain the Water at ſo great a Height, except the Contact of the Periphery of the leſſer Tube, to which the upper Surface of the Water is contiguous. For the Tube *D C*, by the Suppoſition, is not able to ſupport the Water at a greater Height than *B G*.

Fig. 189. *Exp.* 10. When the ſame Tube is inverted, and the Water is rais'd into the lower Extremity of the wider Tube *C D*, it immediately ſinks, if the Length of the ſuſpended Column *D H* be greater than *G B*; whereas in the Tube *D E* it would be ſuſpended to the Height *A F*.

A F. From which it manifeſtly appears, that the Suſpenſion of the Column *D H* does not depend upon the Attraction of the Tube *D E*, but upon the Periphery of the wider Tube, with which its upper Surface is in contact.

For the ſake of thoſe who are pleas'd with ſeeing the ſame Thing ſucceed in different Manners, we ſubjoin the two following Experiments, which are in Subſtance the ſame with the 9*th* and 10*th*.

A B C is a Siphon, in whoſe narrower and ſhorter Leg *A B*, if it were of a ſufficient Length, might be ſuſpended a Column of Water of the Height *E F*; but the longer and wider Leg *B C* will ſuſpend no more than a Column of the Length *G H*. Fig. 190.

Exp. 11. This Siphon being fill'd with Water, and held in the ſame Poſition as in the Figure, the Water will not run out at *C* the Orifice of the longer Leg, unleſs *D C*, the Difference of the Legs *A B* and *B C*, exceed the Length *E F*.

Exp. 12. If the narrower Leg *B C* be longer than *A B*, the Water will run out at *C*, if *D C*, the Difference of the Legs, exceed *E F*; otherwiſe it will remain ſuſpended. Fig. 191.

In theſe two Experiments it is plain, that the Columns *D C* are ſuſpended by the Attraction of the Peripheries at *A*, ſince their Lengths are equal to *E F*, or to the Length of the Column, which by the Suppoſition thoſe Peripheries are able to ſupport; whereas the Tubes *B C* will ſuſtain Columns, whoſe Lengths are equal to *G H*.

Though theſe Experiments ſeem to be concluſive, yet it may not be improper to prevent an Objection, which naturally preſents it ſelf, and which at firſt View may be thought ſufficient to overturn our Theory.

For ſince a Periphery of the Tube *E D* is able to ſuſtain no more than a Column of the Length *A F*, contain'd in the ſame Tube, how comes it to ſuſtain a Column of the ſame Length in the wider Tube *D C*, which is as much greater than the former, as the Section of the wider Tube exceeds that of the narrower? Fig. 188.

Again, if a Periphery of the wider Tube *D C* be able to ſuſtain a Column of Water in the ſame Tube, of the Length *B G*; why will it ſupport no more than a Column of the ſame Length in the narrower Tube *E D*? Fig. 189.

Which Queries may likewiſe be made with regard to the 11*th* and 12*th* Experiments.

The Anſwer is eaſy; for the Moments of thoſe two Columns of Water are preciſely the ſame, as if the ſuſtaining Tubes *E D* and *C D* were continued down to the Surface of the ſtagnant Water *A B*; ſince the Velocities of the Water, where thoſe Columns grow wider, or narrower, are to the Velocities at the attracting Peripheries, reciprocally as the different Sections of the Columns.

Exp. 13. From which Conſideration ariſes this remarkable Paradox, That a Veſſel being given of whatſoever Form, as *A B C*, and containing any aſſignable Quantity of Water, how great ſoever; that whole Quantity of Water may be ſuſpended above the Level, if the upper Part of the Veſſel *C* be drawn out into a capillary Tube of a ſufficient fineneſs.

Fig. 192.

But whether this Experiment will ſucceed, when the Height of the Veſſel is greater than that, to which Water will be rais'd by the preſſure of the Atmoſphere, and how far it will be alter'd by a *Vacuum*, I ſhall give an Account ſome other time.

Having diſcover'd the Cauſe of the Suſpenſion of Water in capillary Tubes, it will not be difficult, to account for the ſeemingly ſpontaneous Aſcent of it; For ſince the Water that enters a capillary Tube, as ſoon as its Orifice is dipt therein, has its Gravity taken off by the Attraction of the Periphery, with which its upper Surface is in contact, it muſt neceſſarily riſe higher, partly by the Preſſure of the ſtagnant Water, and partly by the Attraction of the Periphery immediately above that, which is already contiguous to it.

The Action *of* Glaſs Tubes *upon* Water *and* Quickſilver, *by the* ſame. n. 363. p. 1083.

III. In a former Diſcourſe, I maintain'd, that the Suſpenſion of Water in a capillary Tube was owing to the Attraction of a ſmall annular ſurface on the inſide of the Tube, which touch'd the upper Part of the Water. Among the ſeveral Experiments made uſe of to prove this Aſſertion, was that of a Glaſs Funnel of ſeveral Inches Diameter, having its ſmall End drawn out into a very fine Tube, which Funnel being inverted and fill'd with Water, the whole Quantity of Water therein contain'd was ſuſtain'd above the Level by the Attraction of that narrow *Annulus* of Glaſs, with which the upper Surface of the Water was in contact.

Soon after that Diſcourſe was printed, came out a Book publiſh'd by a Learned and Ingenious Member of this Society, in which that Experiment was accounted for in the following Manner.

Fig. 193.

If there be a Funnel, as A B C, full of Water, and whoſe wide End ſtands in a Veſſel of Water as B C; and the Top of the Funnel A ends in a Capillary Tube open at A, the whole Water will be ſuſtain'd; the Pillar A a by the Attraction of the Circle of Glaſs within the Tube immediately above it; and all the reſt of the Pillars of Water, as F f, D d, E e, G g, &c. in ſome meaſure by the Attraction of the Parts of the Glaſs above them, as F, D, E, G: And that the ſmall Pillars or Threads of Water D d, and E e, do not ſlide down to F f, and G g, and ſo go quite down, ſeems to be owing to their Coheſion with the Pillar A a, which is ſuſtain'd by the Capillary Tube A: For if you break off the ſaid Tube at D E, the whole Water will preſently ſink down.

As this Solution was different from what I had before given, and the Reputation of that Gentleman was ſufficient to give Weight to any of his Opinions; I thought my ſelf under an Obligation to examine his Account of the Experiment, in order either to demonſtrate

its Inſufficiency, or to retract my own Solution. Accordingly at the next Meeting of the Society, I produced the following Experiment.

The Funnel *A F G B C*, whoſe lower Part *B C F G*, was cylindrical to a conſiderable Height, and whoſe Top was drawn out into a fine Tube at *A*, being fill'd with Water to the Height *B F*, ſo that the Surface of the Water *F G*, did not reach to the arched Part of the Funnel; I touch'd the End *A* with a wetted Finger, whereby a ſmall Quantity of Water being inſinuated into the Capillary Tube at *A*, the Water contained in the Funnel was ſuſpended above the Level of the Water in the Ciſtern *D E*, as in the former Experiment. *Fig.* 194.

In this Experiment it is manifeſt, that the little Columns, into which we may ſuppoſe the Cylinder of Water *F G B C*, to be divided, are no way ſuſtain'd by the Attraction of the arched Part of the Glaſs above them, ſince they have no Contact with it. Nor is there any ſuch middle Pillar of Water, which, by its Contact with the Tube at Top, is both ſuſtain'd itſelf, and helps to ſupport the Pillars about it. Upon the Suppoſition of which two Particulars, that Gentleman's Solution was founded.

This Experiment may be thus accounted for: The Cylinder of Water *F G B C*, by its Weight balances a Part of the Preſſure of the Atmoſphere, which is incumbent on the Water in the Ciſtern, and endeavours to force that Cylinder upwards. The reſt of that Preſſure is balanced by the Spring of the Air *A F G*, which is included between the Cylinder of Water *F G B C*, and the little Column of Water in the Capillary *A*. But as this Air by its Spring preſſes equally every Way, it muſt balance as much of the Preſſure of the Atmoſphere upon the little Column of Water at *A*, as it does of that upon the Water in the Ciſtern. The Remainder of the Preſſure of the Atmoſphere upon the Column of Water at *A*, is ſuſtain'd by the Force, with which that Column adheres to the Capillary Tube, which therefore does exactly balance the Weight of the Cylinder of Water *F G B C*, and is the real, though not the immediate, Cauſe of its Suſpenſion.

The Experiment ſucceeds in the ſame Manner, when a Column of Quickſilver is raiſed into the Funnel, inſtead of the Column of Water *F G B C*, the Top of the Tube being touch'd with a wet Finger as before. But then the Height of the Quickſilver in the Funnel muſt be as much leſs than that of the Water, as its ſpecifick Gravity is greater.

I proceed now, according to Promiſe, to examine whether the Experiments therein contain'd, would ſucceed *in Vacuo*; and whether Water could be ſuſpended in a wide Tube by means of a Capillary at Top, at a greater Height than what it can be rais'd to by the Preſſure of the Atmoſphere.

In order to this, I boil'd ſome Water, and afterwards purged it of its Air, by means of the Air-pump; which being done, thoſe Experiments

ments all ſucceeded in the exhauſted Receiver, in the ſame Manner as in the open Air.

The 13*th* Experiment in particular, was made with a Tube of about 35 Inches in Length, and a Quarter of an Inch Diameter, the Top of it being drawn out into a fine Capillary; which being fill'd with Water purged of its Air, as before-mention'd, the whole Quantity continued ſuſpended in the exhauſted Receiver.

This plainly ſhews that the Succeſs of that Experiment does not depend upon the Preſſure of the Air, ſince the ſmall Quantity of Air left in the Receiver, was by no Means capable of ſuſtaining the Water at ſo great a Height, and conſequently that the Height at which Water may be ſuſpended in this Manner, is not limited by that Preſſure.

But here I muſt not omit taking Notice of a conſiderable Difficulty, which preſents itſelf to thoſe who attentively conſider this Experiment. In order to make which the better appear, it will be proper to obſerve, what happens, when a ſimple Capillary Tube is fill'd with Water purged of Air, and inclos'd in the exhauſted Receiver.

Fig. 195. In this Caſe, the whole Column of Water contained in the Tube *A C B*, is ſuſpended by the Attraction of the *Annulus* at the Top of the Tube *A*: And though that *Annnlus* does not immediately act upon any Part of the Water, except what is either contiguous to it, or ſo near as to be within the Sphere of its Attraction, which extends but to a very ſmall Diſtance; yet it is impoſſible that any other Part of the Water, as for Inſtance, that at *C*, ſhould part from the Water above it, and ſink down; becauſe its Deſcent is oppos'd by the Attraction of the contiguous *Annulus* at *C*. For this being equal to the upper *Annulus* at *A*, is capable of ſuſtaining a Column of Water of the Length *A B*, and conſequently is more than ſufficient for ſupporting the Column of Water below it, *C B*. From which it is plain, that no Part of the Water contain'd in the Tube can poſſibly deſcend, unleſs the upper Part, aſſiſted by the Weight of the Water below it, be ſufficient to overcome the Attraction of the *Annulus* of Glaſs at *A*.

Fig. 196. But in ſuch a compound Tube, as that made uſe of in our Experiment, *A C B*, the Caſe is very different, and it does not eaſily appear, why in a *Vacuum* any Part of the Water in the wider Part of the Tube, as for Example at *C*, ſhould not leave that which is above it, and deſcend, ſince the *Annulus* at *C* is by much too wide to ſuſtain a Column of Water of ſo great a Length as *C B*.

The beſt Anſwer I can give to this Difficulty, is, that the Coheſion between the Water contained in the Capillary and that below it, is ſufficient to balance the Weight of the Column ſuſpended. But how far this Coheſion may depend upon the Preſſure of a Medium ſubtile enough to penetrate the Receiver, is worthy of Conſideration. For though

though ſuch a Medium will pervade the Pores of the Water, as well as thoſe of the Glaſs, yet it will act with its intire Preſſure upon all the ſolid Particles, if I may ſo call them, of the Surface of the Water in the Ciſtern; whereas ſo many of the ſolid Particles of the Water in the Tube, which happen to lie directly under the ſolid Particles of the Water above them, will thereby be ſecured from this Preſſure; and conſequently there will be a leſs Preſſure of this Medium upon any Surface of the Water in the Tube below the Capillary, than upon an equal Surface of the Water in the Ciſtern. So that the Column of Water ſuſpended in the Tube may be ſuſtain'd by the Difference between thoſe two Preſſures. This Explication ſeems to be favoured by the following Experiments, which may all be accounted for in the ſame Manner, though I ſhall anon mention another Cauſe, which contributes to the Succeſs of the firſt and ſecond.

The firſt I ſhall mention is the famous Experiment of the Suſpenſion of Mercury purged of Air, to the Height of 70 or 75 Inches in the *Torricellian-Tube*, in the open Air. To which we may add the ſuſtaining of Mercury, likewiſe purged of Air, within the exhauſted Receiver, as related by the learned Monſ. *Papin* in his *Continuation du Digeſteur*. I forbear to mention the Suſpenſion of Water purged of Air, in the *Vacuum*, which he deſcribes in the ſame Book; becauſe there is little Difference between that Experiment and our own above-mentioned; the very Top of the arched Part of his Tube, which Top we may ſuppoſe as ſmall as we pleaſe, ſupplying the Place of the fine Capillary at the Top of our Tube. But we muſt not omit the Experiments made by the famous Monſ. *Huygens* *, of the cohering of poliſhed Plates, with a conſiderable Force in the exhauſted Receiver; as likewiſe of the running of Water and Mercury, when purged of Air, thro' a Siphon of unequal Legs in the *Vacuum*: All which he accounts for from the ſame Principle, and much in the ſame Manner, as we have uſed for explaining the Experiment above.

* Vid. ſupra V. II. p. 24.

As to the Exiſtence of ſuch a Medium, I ſhall content my ſelf to refer to what has been ſaid by Sir *Iſaac Newton* in the Queries at the latter End of the laſt Edition of his *Opticks*: And as I have lately produced ſome Experiments upon Quickſilver, which were exactly the Reverſe of thoſe made by Dr. *Taylor*, the late Mr. *Hawkſbee* and my ſelf upon Water; by which I am now enabled to throw this whole Affair into a little Syſtem by it ſelf, I ſhall lay it down in the following Propoſitions, the Proof of which is contained in the Experiments annexed.

Prop. 1. *The Particles of Water attract one another.*

This, I think, is now univerſally acknowledged, and therefore needs no Demonſtration; the Sphericity of the Drops of Rain, and the running of two Drops of Water into one another upon their Contact, manifeſtly proving it.

Prop.

Prop. 2. *The Particles of Quickſilver attract one another.*

This is likewiſe manifeſt from the Spherical Figure, into which a Drop of Mercury forms itſelf upon a Table; and from two of them immediately running together, as ſoon as they come to touch.

Prop. 3. *Water is attracted by Glaſs.*

This plainly appears from all the Experiments that we have ſhewn upon this Subject.

Prop. 4. *Quickſilver is attracted by Glaſs.*

Experiment 1. If a ſmall Globule of Quickſilver be laid upon a clean Paper, and be touched with a Piece of clean Glaſs; upon drawing the Glaſs gently away, the Quickſilver will adhere to it, and be drawn away with it. And if the Glaſs be lifted up from the Paper, the Quickſilver will be taken up by it, in the ſame Manner as a Piece of Iron is drawn up by the Loadſtone, and will ſtick to the Glaſs by a plain Surface of a conſiderable Breadth, in Proportion to the Bulk of the Drop, as manifeſtly appears by an ordinary Microſcope. Then if the Glaſs be held a little obliquely, the Drop of Mercury will roll ſlowly upon its Axis along the under ſide of the Glaſs, till it comes to the End, where it will be ſuſpended as before.

Exp. 2. If a pretty large Drop of Mercury be laid upon a Paper, and two Pieces of Glaſs be made to touch it, one on each ſide; upon drawing the Glaſſes gently from each other, the Drop of Mercury will adhere to them both, and will be viſibly drawn out from a globular to an oval Shape; the longer Axis paſſing from the middle of thoſe Surfaces, in which the Drop touches the Glaſſes.

Prop. 5. *The Particles of Water are more ſtrongly attracted by Glaſs, than by one another.*

This manifeſtly appears from the riſing of Water in ſmall Tubes above the Level. For when the Water begins to riſe into a Capillary Tube, all the Particles of Water, which touch the ſmall *Annulus* at the Bottom of the Tube, muſt have quitted the Contact of the other Water, and have riſen contrary to their Gravity, to come into Contact with the Glaſs. After the ſame Manner the other Experiments of Dr. *Taylor*, Mr. *Hawkſbee* and my ſelf, upon this Subject, are eaſily explicable. For upon a careful Examination, it will be found in them all, that ſome Parts of the Water quit the Contact of the other Water, and join themſelves to the Glaſs.

Prop. 6. *The Particles of Quickſilver are more ſtrongly attracted by one another, than by Glaſs.*

Fig. 197. *Exp.* 1. If a ſmall Tube as A B, open at both Ends, be dipt into a Glaſs Veſſel fill'd with Mercury, and be held cloſe to the ſide of the Veſſel, that the riſe of the Mercury within it may appear; the Mercury will partly enter into the Tube, but will ſtand within it at ſome Depth, as C E, below the Surface of the Quickſilver in the Veſſel

Veſſel, C D; and this Depth will always be reciprocally as the Diameter of the Tube.

In this Experiment a Column of Quickſilver of the height C E endeavours to force the Mercury higher into the Tube; and as Glaſs has been already prov'd to attract Quickſilver, the Attraction of the annular Surface on the Inſide of the Tube, which is contiguous to the upper Part of the Mercury, will likewiſe conſpire to farther its Aſcent. What oppoſes the Aſcent of the Quickſilver, is the Power by which that Part of it, which endeavours to riſe into the Glaſs, is drawn back by the Attraction of the other Mercury, with which it is in Contact laterally, and this does not only balance the Attraction of the Glaſs, but likewiſe the Weight of the Column of Mercury CE, and conſequently this Attraction is conſiderably ſtronger than the Attraction of the Glaſs.

The Cauſe therefore that ſuſpends the Weight of the Column of Mercury C E, being the Difference between the Attraction of the annular Surface of the Tube at E, and that of an equal Surface of the Quickſilver in the Ciſtern, from which the Mercury, that endeavours to riſe into the Tube, muſt recede, in order to unite itſelf to ſuch an Annulus of the Glaſs, will always be proportional to that annular Surface, or to the Diameter of the Tube. And ſince the Column ſuſtained muſt be proportional to the Cauſe that ſuſpends it, that Column muſt likewiſe be as the Diameter of the Tube. But the Column ſuſpended, is as the Square of the Diameter of the Tube, and the height C E conjointly; from which it follows, that the height C E muſt be as the Diameter of the Tube reciprocally, as it is found to be by Experiment.

The Experiment of the Aſcent of Water above the Level in a Capillary Tube, is juſt the Reverſe of this.

Exp. 2. Quickſilver being poured into the inverted Siphon A C B, Fig. 198. one of whoſe Legs A C is narrower than the other C B; the height C E, at which the Mercury ſtands in the wider Leg C B, is greater than the height C D, at which it ſtands in the narrower Leg C A.

On the contrary, Water ſtands higher in the narrower Leg, than in the wider.

Exp. 3. A B C D repreſents a rectangular Plane of Glaſs, which Fig. 199. makes one ſide of a wooden Box. On the Inſide of this is another Glaſs Plane of the ſame Size, which at the End A C is preſs'd cloſe to the former, and opens to a ſmall Angle at the oppoſite End B D. When Mercury is poured into this Box to any height as C E, it inſinuates itſelf between the two Glaſs Planes, and riſing to different heights between the Glaſſes, where the opening is greater or leſs, it forms the common Hyperbola C G F; one of whoſe Aſymptotes E F is the Line on which the Surface of the Mercury in the Box touches the inner Glaſs; the other is the Line A C, in which the Planes are joined. This Hyperbola being carefully examined by Mr. *Hawkſbee* and my ſelf, the Rectangle E H G, whereſoever taken, proved always equal to itſelf, to as great an Accuracy as could be expected, when

the Planes were opened to any conſiderable Angle: But when the opening was very ſmall, the Inequalities of the Planes, though the beſt I could procure, bearing a greater Proportion than before to the Diſtance between them, occaſioned a ſenſible Variation. Which, by the Way, I take to be the Reaſon why the Ordinates found by the late Mr. *Hawkſbee*, in examining the Curve produced in a contrary Situation, upon dipping two Glaſs-Planes ſo join'd into Spirit of Wine, do not anſwer to thoſe of the Hyperbola.

Fig. 200. *Exp.* IV. A B is a Perpendicular Section through two Glaſs Planes join'd at A, and open'd to a ſmall Angle at B. C repreſents a pretty large Drop of Mercury, the larger the better, which being made to deſcend as far as C, by holding the Planes in an erect Poſture, with the End A downwards, retires from the Contact of the Planes to D, upon inclining the Planes towards an horizontal Situation; and the Diſtance C D becomes greater or leſs, as the Planes are more or leſs inclin'd towards the Horizon.

A Drop of any Oily or Watery Liquor moves the contrary Way, as has been ſhewn by the late Mr. *Hawkſbee*.

Fig. 201. *Exp.* V. A B is a Tube open at both Ends, and a Foot or two in Length, whoſe lower Part is drawn out into a fine Capillary at B. This Tube being filled with Mercury, the whole Column of Quickſilver will be ſuſtained in it, provided the Capillary Tube at B be ſufficiently ſmall. But if the Mercury in the End B be ſuffer'd to touch any other Mercury, it runs all out of the Tube. If, without letting it touch any other Mercury, a ſmall Part of the End B be broken off, the Mercury will run out, till it comes to ſome leſſer height as B C, at which it will again ſtop, the height B C being nearly in a reciprocal Proportion to the Diameter of the ſmall End of the Tube.

The Seventh Experiment in the former Paper is the Reverſe of this.

Fig. 202. *Exp.* VI. Is the ſame in Subſtance with the former, but made with a large Glaſs-Funnel A B, inſtead of a Tube.

The Reverſe of this in Water is the thirteenth Experiment in the former Paper.

In all theſe Experiments it is eaſily ſeen, that the Effect is owing to the Difference between the two Attractions, by which Mercury tends to Glaſs and to its own Body; they being always oppoſed to one another, ſo that a particular Explication is no Way neceſſary. But perhaps it may ſave ſome little Trouble to the Reader, to remove the following Objection, which will readily occur to him.

In the Experiments brought to demonſtrate the fourth Propoſition, the Globule of Mercury adheres to the Glaſs in a Plane Surface, which cannot be done without increaſing the Surface of the Globule, and conſequently removing ſome of its Particles from the Contact of one another. If therefore they tend more ſtrongly to one another than to the Glaſs, why do they not recede from the Glaſs, and aſſume a Figure perfectly Spherical, that they may all have the greateſt poſſible Contact with each other?

To

To this we may anſwer, That the Power, by which Mercury is attracted either by Glaſs, or by other Mercury, is proportional to the attracting Surface; and therefore, though, *cæteris paribus*, the Tendency of Mercury to Glaſs, is not ſo ſtrong as its Tendency to other Mercury, yet in this Caſe a much greater Number of Mercurial Particles coming into Contact with the Glaſs, than what recede from the Contact of one another, it is no Wonder that the Attraction of the Glaſs prevails, and cauſes the Globule to adhere to it. For the Number of Mercurial Particles, which loſe their Contact with the other Mercury, is no more than what makes up the Difference of Surface, which ariſes from changing the Figure of the Drop: Whereas the Particles, which by this Means come to adhere to the Glaſs, are all thoſe that conſtitute the plane Surface, in which the Globule touches it.

Which Conſideration ought likewiſe to be apply'd to the Suſpenſion of Quickſilver in Glaſs-Tubes, either at extraordinary heights in the open Air, or at leſſer heights in a *Vacuum*, as above mentioned. For the Top of the Tube being Spherical, or nearly ſo, it will be found, that the Contact of the Mercury with the Extremity of the Tube, is to the Contact with other Mercury, which would be gained by its leaving the Top of the Tube, and deſcending a very ſmall Space, in a *Ratio* infinitely great; and conſequently that the Contact of the Mercury with the Top of the Tube is one Cauſe of its Suſpenſion.

Corol. 1*ſt.* From this Propoſition it appears, that in a Barometer made with a narrow Tube, the Quickſilver will never ſtand at ſo great a height as in a wider. Which accounts for the *Phænomenon* ſo often mentioned, in the yearly Hiſtory of the Royal Academy of Sciences at *Paris*, by Monſ. *De la Hire*; that in the Barometer, which he conſtantly made uſe of for his annual Obſervations, the Quickſilver did not riſe ſo high, as in another he kept by him, by about three Lines and a half, which is near a third of an Inch our Meaſure: For he tells us, that the Tube of his Barometer is very ſmall. So that there is no Need to have Recourſe to any Peculiarity, either in the Quickſilver or the Glaſs of which that Tube was made; or to an unperceived Remnant of Air left in the Tube, from ſome of which Cauſes that Effect, and ſome others of the ſame kind were imagined to proceed.

Corol. 2*d.* In a Barometer made with a ſmall Tube, the Mercury will riſe and fall irregularly. For, as the height of the Mercury depends partly upon the Diameter of that Part of the Tube that touches the upper Surface of the Mercury; it is plain, that the unavoidable Inequalities in the Diameter of the Tube will be more conſiderable, in Reſpect to the whole Diameter; and conſequently will affect the height of the Mercury, more in a ſmall Tube than in a wider. And this I take to be the Reaſon, why it is ſo very difficult, not to ſay impoſſible to make two Barometers which ſhall exactly agree in the height of the

Quickſilver in all Conſtitutions of the Air, eſpecially if the Tubes be very narrow. This Irregularity is ſtill more conſiderable in the Pendent Barometer, in which the Quickſilver moves through a large Space in order to make a ſmall Alteration in the length of the Column ſuſpended. The ſame Conſideration is eaſily extended to thoſe Levels, that depend upon the riſing of Mercury to the ſame height, in the oppoſite Legs of a bent Tube, an Inſtrument of which kind has been lately offered. And as the Effect is juſt contrary in Levels made with Water or Spirit of Wine, due Regard ought to be had to this Property in the Conſtruction of thoſe Inſtruments, by making the Tubes ſufficiently wide, in order to diminiſh the Error as much as poſſible.

Of the Motion *of* Running Waters, *by the* ſame, n. 355. p. 748.

IV. Aquæ Motum ex imi vaſis foramine defluentis ſæpe videmus, tum in ipſa re Hydraulica, tum in ejus Principiis ad Œconomiam Animalem applicandis, aliis cum potentiis comparari. Cujus Motus quantitatem cum hactenus nemo, quod ſciam, rectè determinaverit, uſurpare ſolent ejus loco ſcriptores Hydraulici Columnæ aqueæ pondus foramini incumbentis. Quod qui faciunt, id ſane neutiquam animum advertunt fieri omnino non poſſe, ut Motus aliquis cum pondere quieſcente conferatur. Poterit autem Aquæ defluentis Motus facili opera definiri hunc in modum.

Fig. 203. Sit SHAHS Aquæ ſuperficies infinita, *CC* foramen circulare in fundo factum, *AB* recta perpendicularis per foraminis centrum ducta, *SGCCGS* Columna ſive Cataracta Aquæ per foramen *CC* decurrentis, *SGC* Curva, cujus rotatione circa Axem *AB* generatur Solidum, ſive Cataracta, *SGCCGS*. Aqua enim cum libere, & motu accelerato deſcendat ad normam corporum omnium gravium, neceſſariò in minorem amplitudinem contrahitur, prout majorem velocitatem acquirit, inter cadendum, & profluit ex foramine *CC* ea cum velocitate, quæ cadendo ab altitudine *AB* comparatur.

Velocitas autem corporis gravis cadendo genita, ex *Galilæi* demonſtratis, rationem obtinet ſubduplicatam altitudinis unde cecidit. Quare, ſi ducatur ad Curvam *SGC* Ordinata quævis *DE*, atque ipſa *DE* vocetur y, & *AD* x, exponetur velocitas Aquæ in ſectione *EE* per $\sqrt{x}$, & Factum ex ea velocitate ducta in ipſam ſectionem per $\sqrt{x} \times y^2$.

Quod factum eſt ut moles Aquæ dato temporis ſpatio per eam ſectionem tranſeuntis; cumque eadem Aquæ moles dato tempore per ſingulas Cataractæ ſectiones tranſeat, proinde Factum iſtud perpetuo ſibi conſtabit, eritque $\sqrt{x} \times y^2 = 1$, & $x\,y^4 = 1$.

Quæ eſt Æquatio Curvæ *SGC*, cujus partem, intra datum vas comprehenſam, delineavit, ejuſdemque Æquationem non obſcurè indicavit Magnus *Newtonus*, *Prop.* 36. *Libr.* 2. *Princip.* qui primus omnium veram Aquæ effluentis velocitatem, ex genuinis Principiis deductam, Orbi Literato expoſuit.

Eſt

Eſt autem ipſa Curva Hyperboloides quarti Ordinis, cujus altera Aſymptotos eſt recta *AS* ad Horizontem parallella, altera *AB* eidem perpendicularis.

Hujus Poteſtas eſt Quadrato-Cubus Ordinatæ *FG*, ductæ ad punctum *G*; ubi recta *AG*, biſecans angulum ab Aſymptotis comprehenſum, Curvæ occurrit.

Spatium *SADES*, inter Curvam *SGE*, Ordinatam *DE* & Aſymptotos *AD*, *AS* incluſum, æquale eſt quatuor partibus tertiis Rectanguli *HD*, ſub Abſciſſa *AD* & Ordinata *DE* contenti. Eſtque proinde Spatium *SHE* pars tertia ejuſdem Rectanguli.

Solidum *SGEEGS*, convolutione ſpatii *SADES*, circa Axem *AD*, generatum, duplum eſt Cylindri incumbentis ſectioni *EE*. Unde Solidum cavum, quod gignit converſio ſpatii *SHEGS*, circa eundem Axem, Cylindro incumbenti æquale eſt. Quæ omnia facili calculo inveniuntur per Methodum Fluxionum inverſam.

Theorema 1. Aqua ex vaſe amplitudinis infinitæ, per foramen circulare in fundo factum, decurrente, Motus totius Cataractæ aqueæ Horizontem verſus æqualis eſt Motui Cylindri aquei, ſub ipſo foramine & altitudine Aquæ, cujus velocitas æquet velocitatem Aquæ per foramen effluentis, vel æqualis eſt Motui molis Aquæ, quæ dato quovis tempore effluit, cujus ea ſit velocitas, qua percurratur eodem dato tempore ſpatium æquale altitudini Aquæ.

Demonſtratio primæ partis. Ducatur ad Curvam *SGC* alia Ordinata *dc*, priori *DE* quam proxima.

Curvâ circa Axem *AB* conversâ, generabunt Ordinatæ *DE*, *de*, Circulos duos, quibus intercipitur Solidum naſcens *EEee*. Id ſolidum æquale eſt Facto ex altitudine *Dd* ducta in ſectionem *EE*, & Motus ejus æquatur Facto ex ipſo ſolido ducto in velocitatem ejuſdem, ſive Facto ex altitudine *Dd*, ſectione *EE*, & velocitate Aquæ in ea Sectione. Cumque ſupra oſtenſum ſit, Factum ex quavis Sectione Cataractæ velocitate Aquæ in ea Sectione, quantitatem eſſe conſtantem, erit proinde Motus totius Cataractæ æqualis Facto ex quantitate illa conſtante ducta in Summam omnium altitudinum *Dd*, ſive in ipſam *AB*, hoc eſt, motui Cylindri ſub ipſo foramine & altitudine Aquæ, cujus velocitas æquet velocitatem Aquæ per foramen effluentis. *Q. E. D.*

Corol. 1. Data altitudine Aquæ, erit Motus Cataractæ in ratione foraminis.

2. Dato foramine, erit Motus Cataractæ in ratione ſeſcuplicata altitudinis, ſive in ratione triplicata velocitatis, qua Aqua per foramen exit.

3. Dato Motu Cataractæ, erit foramen reciprocè in ratione ſeſcuplicata altitudinis, vel reciprocè in ratione velocitatis triplicata.

Demonſtratio ſecundæ partis. Moles Aquæ dato tempore effluentis eſt ad Cylindrum ſub ipſo foramine & altitudine Aquæ, ut longitudo, quam Aqua effluens æquabili velocitate dato iſto tempore percurſura ſit,

ſit, ad altitudinem Aquæ. Cumque velocitas, quæ tribuitur moli Aquæ effluentis, ſit ad velocitatem Cylindri reciprocè in eadem ratione, erunt Motuum quantitates utrinque æquales. *Q. E. D.*

Corol. 1. Data altitudine Aquæ & mole effluente, Motus Cataractæ eſt in ratione inverſa temporis quo iſta moles effluit.

2. Data altitudine & tempore, Motus Cataractæ eſt ut moles Aquæ tempore iſto effluentis.

3. Dato tempore & mole Aquæ effluentis, erit Motus Cataractæ in ratione altitudinis.

4. Dato Motu Cataractæ & altitudine, moles effluens eſt in ratione temporis.

5. Dato Cataractæ Motu & mole Aquæ effluentis, altitudo eſt ut tempus.

6. Dato tempore & Motu Cataractæ, erit Aquæ effluentis moles reciprocè ut altitudo.

Fig. 204. *Theorema* II. Si capiatur BA, quæ ſit ad BD, ut DG^4 ad $DG^4 - BC^4$; Aqua decurrente ex dato vaſe Cylindrico ſemper pleno $GGEE$, per foramen circulare CC in fundo medio factum. Motus Cataractæ aqueæ Horizontem verſus æqualis erit Motui Cylindri ſub foramine & altitudine AB, cujus velocitas æquet velocitatem Aquæ per foramen exeuntis; vel erit æqualis Motui molis Aquæ quæ dato quovis tempore effluit, cujuſque ea ſit velocitas, qua percurratur eodem dato tempore ſpatium æquale altitudini AB.

Demonſtratio primæ partis. Ducatur AS ipſi DG parallella, & Aſymptotis AS, AB, per puncta G, C deſcripta concipiatur Curva *Newtoniana* SGC.

Ut conſtet Aquæ altitudo, ſupplendus eſt exeuntis locus Cylindro aqueo $ggGG$, deſcendente cum ea velocitate uniformi, quæ acquiritur cadendo ab A ad D, quemadmodum docet Vir incomparabilis Propoſitione prædicta.

Motui hujus Cylindri æquatur, per Theorema ſuperius, Motus Cataractæ $SSGG$. Ergo Motus Aquæ deſcendentis, cum ſit compoſitus ex Motu Cylindri aquei $ggGG$, & Motu Cataractæ $GGCC$, æqualis eſt Motui Cataractæ integræ $SGCCGS$, *h. e.* per Theorema primum, Motui Cylindri aquei ſub foramine & altitudine AB, cujus velocitas æqualis ſit velocitati Aquæ per foramen decurrentis. *Q. E. D.*

Pars ſecunda ſequitur ex priore.

Corol. 1. Oriuntur hinc omnia Propoſitionis præcedentis Corollaria, ſubſtituendo altitudinem AB, pro Aquæ altitudine.

2. Si vas alia figura fuerit, atque Cylindrica; aut foraminis figura pro circulari fuerit quadrata, triangularis, vel qualiſcunque; aut ipſum foramen non ſit in medio fundo ſitum, vel etiam in latere vaſis factum; idem erit Motus Cataractæ, ſcilicet æqualis Motui Priſmatis aquei ſub foramine & altitudine AB, cujus velocitas par ſit velocitati Aquæ effluentis. Nam eadem Aquæ moles, cum eadem velocitate atque

que in priori Hypotheſi, tum per ipſum foramen, tum per ſingulas Cataractæ ſectiones tranſibit.

3. Si vaſis Diameter permagnam rationem obtineat ad Diametrum foraminis, negligi poterit altitudo *A D*, & vaſis ipſius altitudo pro altitudine Cylindri, vel Priſmatis aquei, uſurpari.

Hactenus caſum illum particularem, quo Aqua, Gravitatis vi, ex vaſe defluit, ſeorſim conſideravimus. Id eo fecimus lubentius, tum quod illum fere ſolum adhibere ſoleant Mathematici, quoties agitur de Fluidorum impetu, tum quod Curvæ Hyperbolicæ ſupra expoſitam proprietatem, qua Cataractam Aquæ deſcendentis format, non indignam cenſeamus contemplatione Geometrarum. Alioqui potuiſſet iſte caſus nullo negotio deduci ex Theoremate generali, quod proximo loco proponemus.

Theorema III. Aqua fluente per Canalem plenum quemcunque *A B C D* ſecundum lineam *E F*, cui ſit perpendiculare utrumque Canalis orificium *A B* & *C D*, Motus Aquæ verſus Orificium *C D*, ſive Motus impedimenti, quod in ipſo orificio oppoſitum ſiſtat Motum totius Aquæ, æqualis eſt Motui Priſmatis aquei ſub qualibet Sectione Canalis *C H* & linea directionis, ſive longitudine Canalis *E F*, quod moveatur eadem cum velocitate, qua Aqua fluit per iſtam Sectionem; ſive æqualis Motui molis Aquæ, quæ dato quovis tempore effluit ex Canali, cujuſque ea ſit velocitas, qua percurratur eodem dato tempore ſpatium æquale longitudini Canalis. Fig. 205.

Caſ. 1. Sit linea directionis recta quævis *E F*.

Facile demonſtratur pars prima eodem modo, quo Theorema primum. Eſt enim Factum ex quavis ſectione Canalis *C H*, & Aquæ velocitate in ea Sectione, quantitas conſtans.

Pars ſecunda ſequitur ex prima.

Caſ. 2. Si linea directionis *A B C D E*, ex pluribus rectis *A B*, *B C*, *C D*, *D E*, ad ſeſe invicem inclinatis ſit compoſita, idem erit Aquæ Motus. Nam Motus Aquæ in toto Canali compoſito *A B C D E*, conficitur ex Motibus Aquæ in partibus Canalis *A B*, *B C*, *C D*, *D E*, additis ſibi invicem. Statuimus autem Aquam fluentem ſecundum rectam *A B*, mutata iſta directione in aliam, qua feratur ſecundum rectam *B C*, nihil ex Motu deperdere. Leges enim illas, quæ in motu corporum ſolidorum obſervantur, quoties eorundem directio mutatur, fluida non ſequuntur. Alioqui fluidum mutata directione in aliam priori perpendicularem, penitus ſiſteretur, quod Experimentis neutiquam deprehenditur. Aqua porro ex Vaſis foramine exiliens, ſive deorſum, ſive ſecundum Horizontis planum, ſive rectâ ſurſum feratur, eandem obtinet velocitatem. Quod ſi aliquando vel ratiocinio ſubtiliori, vel Experimentis innoteſcet, aliquam Motus imminutionem ex mutata directione proficiſci, erit ejuſdem ratio habenda. Fig. 206.

Si Curva fuerit linea directionis *A B*, referetur ad hunc Caſum, quippe quæ ex pluribus rectulis confecta concipi queat, *Fig.* 207. Fig. 207.

Caſ. 3.

Caſ. 3. Si diviſus fuerit Canalis *AB* in plures ramos *BC*, *BD*, *BE*, longitudine æquales, eadem ratione invenietur Aquæ Motus, uſurpando pro linea directionis longitudinem *ABD*, compoſitam ex longitudine Canalis principis *AB*, & longitudine cujuſvis rami *BD*. Perinde autem eſt, ſive Aqua à Canali principe verſus ramos, ſive à ramis fluxerit verſus principem Canalem. Quod ſi rami fuerint inæquales, inveniendus eſt Motus Aquæ in ſingulis ramis, adhibendo pro linea directionis longitudinem confectam ex longitudine cujuſque rami, & longitudine principis Canalis.

Fig. 208.

Nullo negotio deducitur ex Caſu ſecundo.

Caſ. 4. Si rami æquales, in quos diſtributus eſt Canalis *AB*, iterum in Canalem unicum *FG* colligantur, ad Motum Aquæ inveniendum adhibenda eſt pro linea directionis longitudo integra *ABDFG*, confecta ex longitudine principis Canalis *AB*, rami cujuſvis *BDF*, & Canalis recompoſiti *FG*. Si Rami ſint inequales, inveniendus eſt in ſingulis Aquæ Motus, & eorum Motuum Summa Motui Aquæ in Canali recompoſito addendus. Sequitur ex Caſu 2, & 3.

Fig. 209.

Corol. 1. Data longitudine Canalis, & qualibet Sectione ejuſdem, erit Motus Aquæ in ratione velocitatis qua Aqua fluit per iſtam Sectionem.

2. Data quavis Sectione, & velocitate Aquæ Sectionem iſtam præterfluentis, erit Motus Aquæ ut longitudo Canalis.

3. Data Canalis longitudine, & velocitate Aquæ in quavis Sectione, erit Aquæ Motus in ratione illius Sectionis.

4. Dato Motu Aquæ, & aliqua Sectione, erit longitudo Canalis in ratione inverſa velocitatis.

5. Dato Aquæ Motu, & longitudine Canalis, erit Sectio quævis reciprocè ut velocitas.

6. Data velocitate in qualibet Sectione, & Motu Aquæ, erit iſta Sectio in ratione reciproca longitudinis.

7. Data longitudine Canalis, & mole Aquæ certo quovis tempore effluentis, erit Aquæ Motus reciprocè ut iſtud tempus.

8. Data Canalis longitudine, & tempore, erit Aquæ Motus ut moles effluens.

9. Dato tempore, & mole Aquæ effluentis, erit Aquæ Motus ut longitudo Canalis.

10. Dato Motu Aquæ, & longitudine Canalis, moles effluens eſt in ratione temporis.

11. Dato Aquæ Motu, & mole effluente, erit tempus ut Longitudo Canalis.

12. Dato tempore, & Motu Aquæ, erit moles effluens reciprocè ut longitudo Canalis.

13. Si binæ moles Aquæ motu contrario in directum occurrant, & pares ſint utrinque tum ſuperficies quibus in ſe invicem impingant, tum velocitates quibus iſtæ ſuperficies in adverſum moveantur, fuerit autem altera moles Aquæ guttulæ uni æqualis, altera Aqua omnis Oceano contenta,

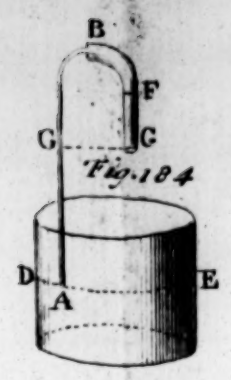


Fig. 184

Fig. 192

Fig. 198

Fig. 184

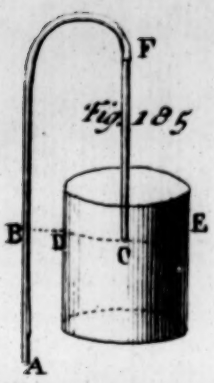


Fig. 185

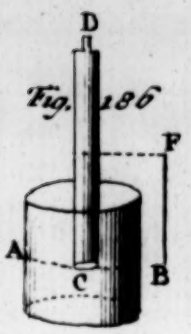


Fig. 186

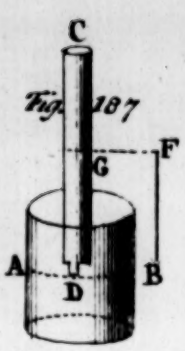


Fig. 187

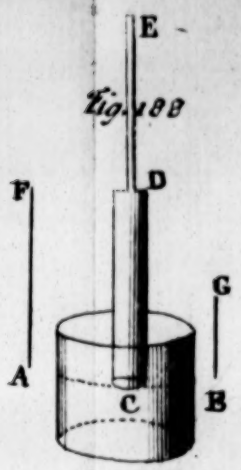


Fig. 188

Fig. 189

Fig. 190

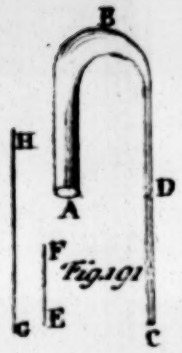


Fig. 191

Fig. 192

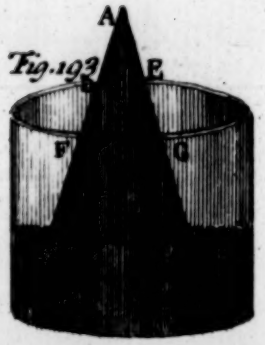


Fig. 193

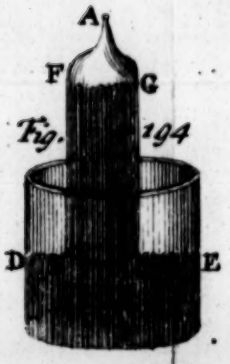


Fig. 194

Fig. 195

Fig. 196

Fig. 197

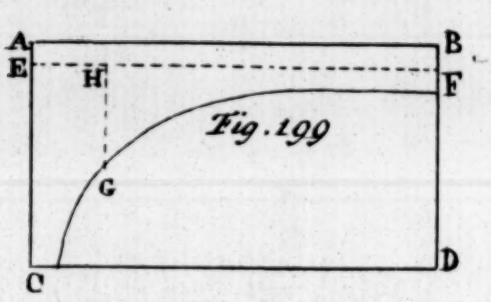


Fig. 199

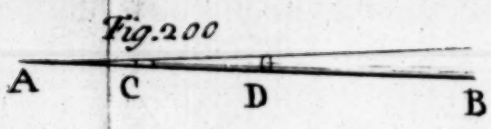


Fig. 200

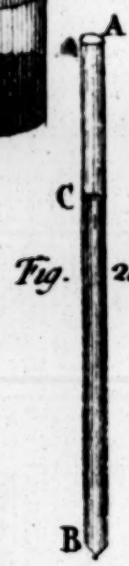


Fig. 201

Fig. 202

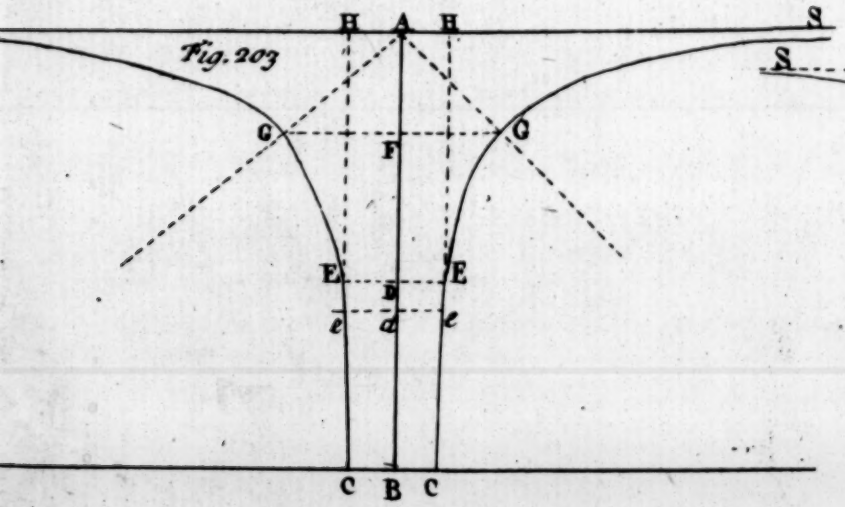
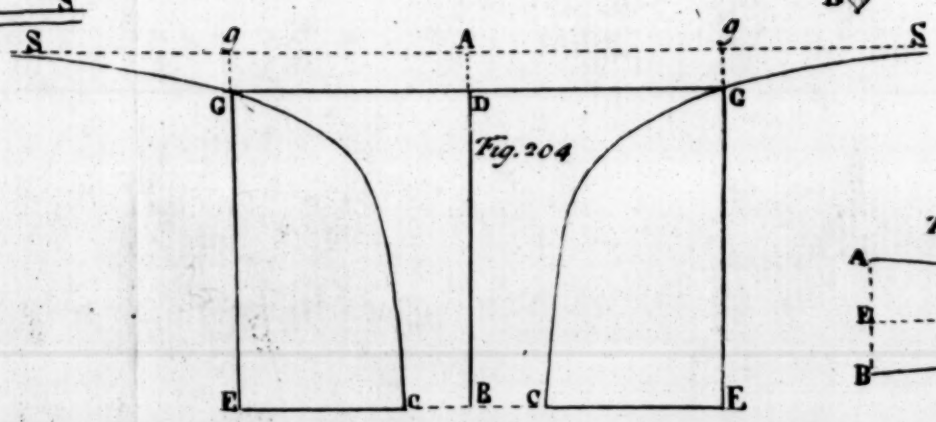


Fig. 203



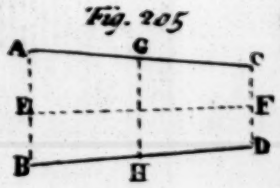


Fig. 205

Fig. 206

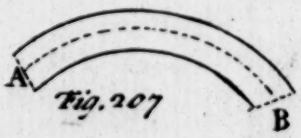


Fig. 207

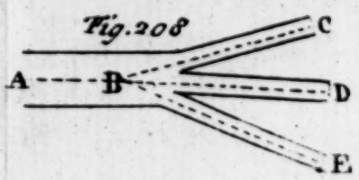


Fig. 208

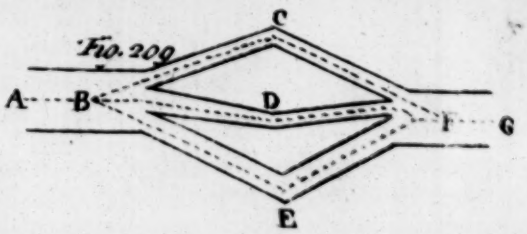


Fig. 209

Caſ. 3. Si diviſus fuerit Canalis *AB* in plures ramos *BC*, *BD*, *BE*, longitudine æquales, eadem ratione invenietur Aquæ Motus, ſurpando pro linea directionis longitudinem *ABD*, compoſitam ex longitudine Canalis principis *AB*, & longitudine cujuſvis rami *BD*. Perinde autem eſt, ſive Aqua à Canali principe verſus ramos, ſive à ramis fluxerit verſus principem Canalem. Quod ſi rami fuerint inæquales, inveniendus eſt Motus Aquæ in ſingulis ramis, adhibendo pro linea directionis longitudinem confectam ex longitudine cujuſque rami & longitudine principis Canalis. Fig. 208.

Nullo negotio deducitur ex Caſu ſecundo.

Caſ. 4. Si rami æquales, in quos diſtributus eſt Canalis *AB*, iterum in Canalem unicum *FG* colligantur, ad Motum Aquæ inveniendum adhibenda eſt pro linea directionis longitudo integra *ABDFG*, facta ex longitudine principis Canalis *AB*, rami cujuſvis *BD* & Canalis recompoſiti *FG*. Si Rami ſint inæquales, inveniendus eſt in ſingulis Aquæ Motus, & eorum Motuum Summa Motui Aquæ in Canali recompoſito addendus. Sequitur ex Caſu 2, & 3. Fig. 209.

Corol. 1. Data longitudine Canalis, & qualibet Sectione ejuſdem erit Motus Aquæ in ratione velocitatis qua Aqua fluit per iſtam Sectionem.

2. Data quavis Sectione, & velocitate Aquæ Sectionem iſtam perfluentis, erit Motus Aquæ ut longitudo Canalis.

3. Data Canalis longitudine; & velocitate Aquæ in quavis Sectione, erit Aquæ Motus in ratione illius Sectionis.

4. Dato Motu Aquæ, & aliqua Sectione, erit longitudo Canalis in ratione inverſa velocitatis.

5. Dato Aquæ Motu, & longitudine Canalis, erit Sectio quævis reciprocè ut velocitas.

6. Data velocitate in qualibet Sectione, & Motu Aquæ, erit iſta Sectio in ratione reciproca longitudinis.

7. Data longitudine Canalis, & mole Aquæ certo quovis tempore effluentis, erit Aquæ Motus reciprocè ut iſtud tempus.

8. Data Canalis longitudine, & tempore, erit Aquæ Motus ut mole effluens.

9. Dato tempore, & mole Aquæ effluentis, erit Aquæ Motus ut longitudo Canalis.

10. Dato Motu Aquæ, & longitudine Canalis, moles effluens eſt in ratione temporis.

11. Dato Aquæ Motu, & mole effluente, erit tempus ut Longitudo Canalis.

12. Dato tempore, & Motu Aquæ, erit moles effluens reciprocè ut longitudo Canalis

13. Si binæ moles Aquæ motu contrario in directum occurrant, & pares ſint utrinque tum ſuperficies quibus in ſe invicem impingant, tum velocitates quibus iſtæ ſuperficies in adverſum moveantur, fuerit autem altera moles Aquæ guttulæ uni æqualis, altera Aqua omnis Oceano contenta

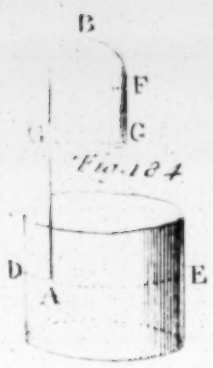


Fig. 194

C

Fig. 192

A

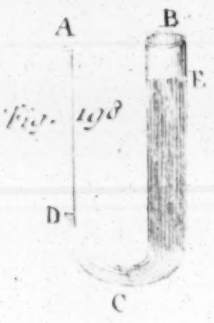


Fig. 193

S

Fig. 200

A B C

Fig. 184

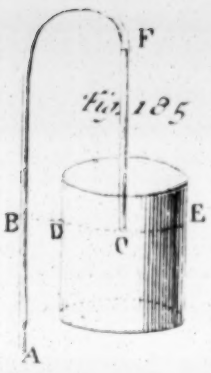


Fig. 185

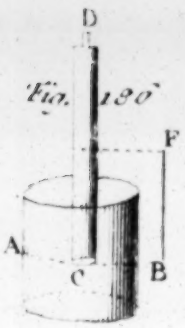


Fig. 186

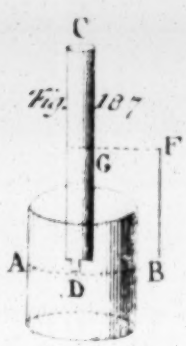


Fig. 187

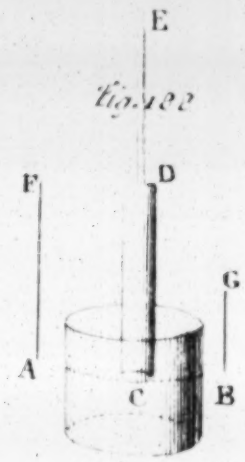


Fig. 188

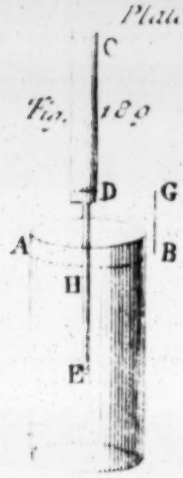


Fig. 189

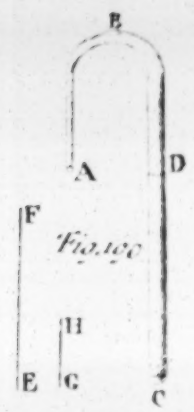


Fig. 190

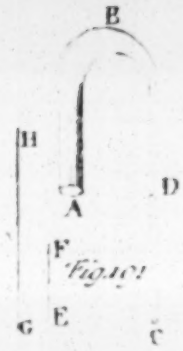


Fig. 191

Fig. 192

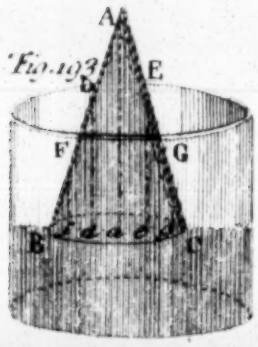


Fig. 193

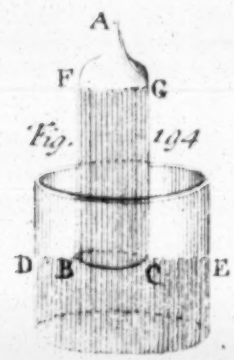


Fig. 194

Fig. 195

Fig. 196

Fig. 197

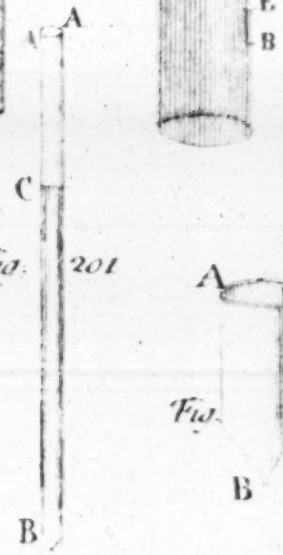
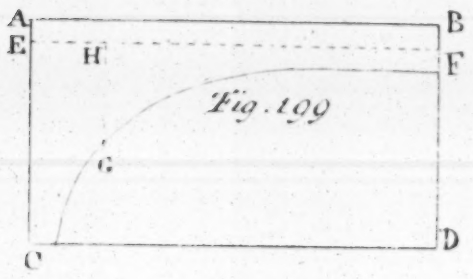


Fig. 201



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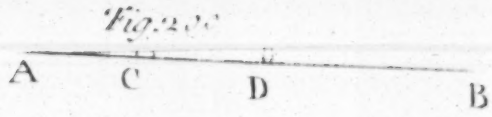
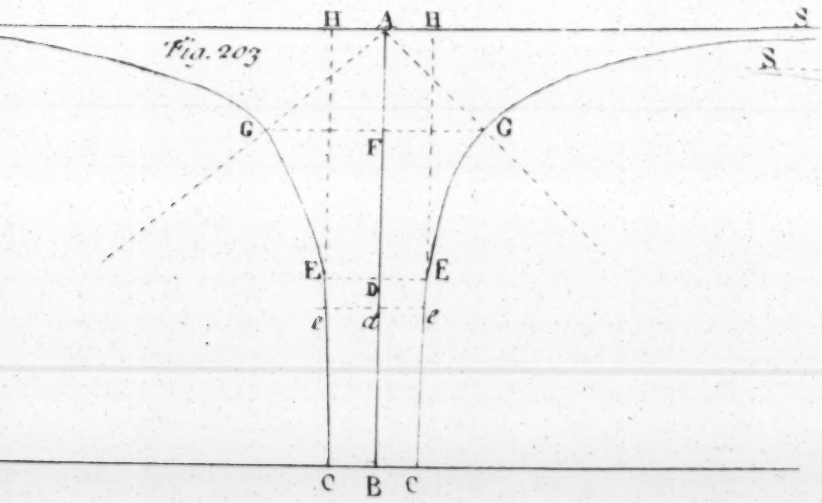


Fig. 200

Fig. 202



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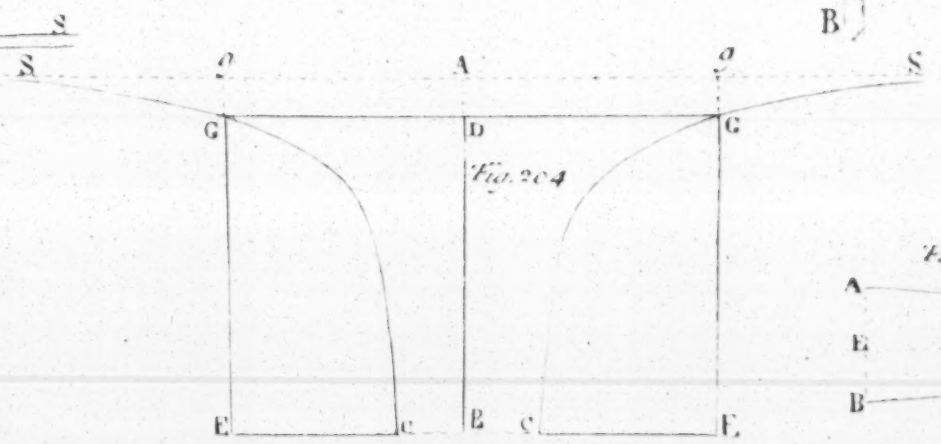

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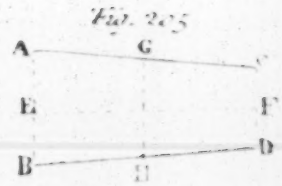

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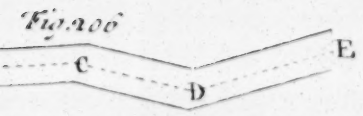

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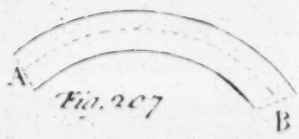


Fig. 207

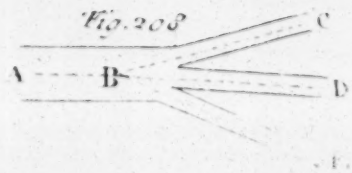


Fig. 208

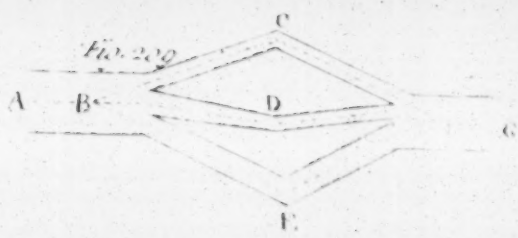


Fig. 209

contenta, vel etiam quantitas Aquæ infinita; fieri poteſt ut una iſta guttula Aquam omnem Oceani, vel quantitatem Aquæ infinitam, non ſolum ſuſtineat, ſed poſt occurſum, eadem ac prius velocitate, ipſa in plagam eandem moveri pergat, eadem illam in partes contrarias repellat. Quod eſt mirabile Paradoxon in re Hydraulica.

14. Si certa moles Aquæ, per canalem ex tubis duobus cylindricis, Diametro inæqualibus, compoſitum, à tubo ampliore verſus anguſtiorem fluat, & motus Aquæ neque minuatur inter fluendum neque augeatur, ſimul ac prima pars Aquæ tubi minoris initium ingreſſa fuerit, ſtatim tardius fluere incipiet, & continuato effluxu ex tubo latiore in anguſtiorem, gradatim magis retardabitur Aqua in tubo anguſtiore, uſque dum tota in eum tubum pervenerit. Contrario modo res eveniet, fluente Aqua à tubo minore verſus ampliorem. Quod eſt alterum Paradoxon in re Hydraulica. Ponitur autem Aqua ubique ſibi cohærere.

Oriuntur bina iſta Corollaria ex Caſu 1.

15. Ex Caſu ſecundo datur Methodus æſtimandi Motum Sanguinis in qualibet Arteria. — *Of the* Motion *of the* Blood *in the* Arteries.

16. Datis quibuſcunque Arteriis binis, æqualem Sanguinis molem tranſmittentibus, major eſt impetus Sanguinis in Arteria à Corde remotiore quam in propiore. Quod eſt Paradoxon notatu dignum in Œconomia Animali.

17. Ex Caſu tertio oritur alterum Paradoxon in Œconomia Animali, nempe majorem eſſe Sanguinis motum ſive impetum, in Arteriis omnibus Capillaribus ſimul ſumptis, quam in ipſa Aorta. Item, major eſt in Capillaribus Venis, quam Arteriis.

18. Ex Caſu quarto deducitur Methodus definiendi motum Sanguinis in quavis Vena.

19. Ex eodem deducitur tertium in Œconomia Animali Paradoxon, nempe majorem eſſe Sanguinis impetum in Vena quavis, quam in Arteria ei Venæ reſpondente, & proinde majorem eſſe in Vena Cava, quam in Aorta.

Problema I. Invenire motum Aeris ex Pulmone effluentis. — *Of the* Motion *of the* Air *flowing out of the* Lungs *in* Expiration.

Sit l = Longitudo totius ductus aerei, ab Ore & Naribus ad extremos ramos Trachææ.

q = Quantitas Aeris mediocri expiratione ex Pulmone emiſſa.

$\mathcal{Q}$ = Aeris copia validiſſima expiratione expulſi.

t = Tempus mediocris exſpirationis.

$\mathcal{T}$ = Tempus exſpirationis fortiſſimæ.

Inde, per Theorema 3. *Caſ.* 3. Motus Aeris ex Pulmone effluentis

in exſpiratione mediocri $= \frac{q\,l}{t}$.

fortiſſima $= \frac{\mathcal{Q}\,l}{\mathcal{T}}$.

Hoc eſt, Motus Aeris ex Pulmone exeuntis æqualis eſt motui molis Aeris, quæ unica expiratione emittitur, cujus ea ſit velocitas, qua percurratur tempore exſpirationis longitudo totius Canalis Aerei. *Q. E. I.*

Aeris quantitatem expiratione mediocri emiſſam Vir Clariſſimus, *Alphonſus Borellus*, facto Experimento 18 circiter, vel 20 unciis cubicis definit. Eſt autem diverſa, non ſolum in diverſis Hominibus, ſed etiam temporibus diverſis, in Homine eodem. Ipſe Experimentum in hunc modum inſtitui.

Veſicæ madefactæ à parte inferiore pondus appendebam, & aptato eidem ſuperius tubo vitreo Diametro circiter unciali, naribus obturatis Aerem veſicæ leniter inſpirabam, per ſpatium trium minutorum ſecundorum, pondere interim in menſa quieſcente. Poſtea Veſicam cum Aere incluſo & pondere appenſo, ſub Aquam in vaſe Cylindrico contentam, demergebam, notata diligenter altitudine, ad quam Aqua attollebatur. Deinde, Aere ex veſica expreſſo, iterum eandem cum pondere in Aquam immittebam. Quod cum eſſet factum, facilè inveniebatur Aquæ moles, quæ vaſi infuſa altitudinem prius notatam conficeret. Experimento decies repetito, & additis ſibi invicem quantitatibus ſingulis inventis, earum decima, ſive media moles Aquæ vaſi infuſa, reperiebatur 35 unciis cubicis æqualis. Quæ moles eſt Aeris veſica contentæ; & adjecta circiter parte duodecima, ſeu 3 unciis cubicis, ob Aeris condenſationem à frigore Aquæ factam, cum tempeſtas fuerit hyemalis, efficiuntur 38 unciæ cubicæ. Præterea addendum eſt tantillum, tum propter Aquæ preſſionem in veſicam, tum ob Vaporem qui cum halitu emittitur in humorem coactum; quod fiat neceſſe eſt ex frigore Aquæ, & veſicæ madidæ contactu. Æſtimavi igitur Aeris copiam, leni expiratione emiſſam tempore trium minutorum ſecundorum, numero rotundo 40 unciarum cubicarum.

In exſpiratione validiſſima exſpirabam uncias cubicas 125, tempore minuti ſecundi unius.

Hujuſmodi autem exſpiratione, cum vehementi Pulmonis contentione ad ſtrangulatum fere continuata, 220 uncias cubicas ex Pectore emittebam. Unde patet, ut id obiter moneam, multò plus Aeris in Pectore ſupereſſe, quam unica exſpiratione mediocri emitti.

Si ergo ponatur $l = 2$ pedes

$q = 40$ unciæ cubicæ

$Q = 125$ unciæ cubicæ

$t = 3''$

$T = 1''$

Aeris Gravitas Specifica ad Gravitatem Aquæ, ut 1 ad 1000.

Pes Aquæ cubicus = 1000 unc. *Avoird.*

Erit Motus mediocris Aeris Pulmone exeuntis æqualis motui ponderis Scrupulorum 4 & Granorum 9, quod percurrat unciam unam minuto ſecundo; vel motui ponderis Grani $1\frac{1}{3}$, quod eodem tempore conficiat longitudinem 5 pedum & 7 unciarum. Quæ eſt velocitas Aeris

ris per Laryngem effluentis, poſita Laryngis Sectione $= \frac{1}{5}$ unciæ quadratæ.

Motus maximus Aeris Pectore expulſi æquatur motui ponderis unciæ $1\frac{3}{4}$ circiter, percurrentis unciam unam minuto ſecundo; ſive motui ponderis grani $1\frac{1}{3}$ percurrentis eodem tempore 52 pedes. Quæ eſt velocitas Aeris in fortiſſima exſpiratione per Laryngem erumpentis.

Corol. 1. Data Aeris copia & longitudine Canalis aerei, motus Aeris eſt in ratione inverſa temporis exſpirandi.

2. Data mole Aeris & tempore, erit motus in ratione directa longitudinis.

3. Data longitudine & tempore, motus eſt ut Aeris copia.

4. Dato motu & Aeris copia, erit longitudo in ratione directa temporis.

5. Dato motu & longitudine, erit Aeris moles directè ut tempus.

6. Dato motu & tempore, erit Aeris moles reciproce ut longitudo Canalis aerei.

7. Motus Aeris eſt in ratione compoſita ex ratione quadruplicata Diametri cujuſvis homologæ ipſius Animalis, & ratione inverſa temporis exſpirandi; vel in ratione compoſita ex ratione ponderis totius Animalis, ratione ejuſdem ponderis ſubtriplicata, & ratione temporis reciproca.

Nam pondus Animalis, Diametri cujuſvis homologæ Cubus & moles Aeris expulſi ſunt in eadem ratione. Ponitur autem Corpora Animalium Machinas eſſe ſimiliter factas.

Scholium. Longitudinem hic uſurpatam, vel ipſam eſſe concipies Canalis aerei longitudinem, ſi Rami omnes Trachææ longitudine æquales ponantur; vel mediam inter longitudines diverſas, ſi Rami ſint inæquales.

Problema II. Determinare impetum, ſive impreſſionem quam excipit interna Pulmonum ſuperficies ab Aere exſpirando.

Cum actioni æqualis & contraria ſit reactio; neceſſe eſt, ut, quanto motu urgetur ab interna Pulmonum ſuperficie Aer exſpirandus, tanto viciſſim ab Aere repellatur ſuperficies Pulmonum.

Unde, per Problema ſuperius, impetus dictus in exſpiratione

mediocri $= \frac{q\,l}{t}$

fortiſſima $= \frac{\mathcal{Q}l}{\mathcal{T}}$. *Q. E. I.*

Hinc poſitis iiſdem quæ in ſuperiore ponuntur, impetus mediocris Aeris in Pulmones æqualis eſt motui ponderis drachmæ circiter $1\frac{1}{2}$, quod minuti ſecundi ſpatio percurrat unciam unam; vel motui ponderis 19 librarum, conficientis eodem tempore $\frac{1}{16}\frac{1}{4\frac{1}{2}}$ unciæ, quæ eſt velocitas Aeris in contactu ſuperficiei Pulmonis internæ. Ponimus

autem cum Viro Doctiſſimo *Jacobo Keilio* ſuperficiem Pulmonis internam 21900 circiter unciis quadratis æqualem.

Impetus vero maximus Aeris in Pulmones æquatur motui ponderis unciæ circiter $1\frac{1}{4}$ moti unciam unam minuto ſecundo; vel motui ponderis 19 librarum, quod partem $\frac{1}{175}$ unciæ conficiat eodem tempore. Quæ eſt Aeris velocitas ad ſuperficiem Pulmonis in exſpiratione vehementi.

Corol. 1. Sequuntur ex hac Propoſitione Corollaria præcedenti ſubjuncta.

2. Impetus mediocris incumbens in partem ſuperficiei Pulmonis, quæ ſit ipſi Laryngis Sectioni æqualis, eſt motus ponderis $\frac{1}{1152}$ grani, conficientis unciæ ſpatium minuto ſecundo; vel motus grani $1\frac{1}{2}$ quod eodem tempore pecurrat unciæ partem $\frac{1}{1624}$. Impetus autem maximus in parem ſuperficiem eſt motus ponderis $\frac{1}{1331}$ partis grani, quod unciam unam, vel motus ponderis grani $1\frac{1}{3}$ quod $\frac{1}{175}$ unciæ ſingulis minutis ſecundis conficiat.

3. Impetus Aeris in mediocri exſpiratione in Pulmones impreſſus, æquatur motui Columnæ aqueæ percurrentis unciam unam minuto ſecundo, cujus Columnæ baſis eſt ipſa Pulmonum ſuperficies interna, altitudo autem eſt $\frac{1}{68136}$ unciæ. Eſtque Columnæ altitudo pars $\frac{1}{73000}$ unciæ, in exſpiratione omnium vehementiſſima.

4. Impetus incumbens in ſuperficiem parem circulo maximo Globuli Sanguinei, in leni exſpiratione, eſt pars $\frac{1}{144}$ ponderis Globuli Sanguinei; in exſpiratione vehementi $\frac{2}{3}$ ejuſdem ponderis, moti unciam unam minuto ſecundo. Qua autem ratione Diametros Globulorum Sanguinis dimenſus ſim, cum uſui eſſe queat ad aliorum Objectorum minimorum magnitudines definiendas, libet obiter exponere. Capillum tenuem, & ſatis longum aciculæ pluries circumvolvi, ut omnes convolutiones ſeſe invicem accurate contingerent, quod admotum ſubinde Microſcopium luculenter oſtendebat. Deinde cum inter capedinem inter extremas utrinque circumvolutiones Circino cepiſſem, eandem Scalæ, quam vocant, Diagonali applicabam, ſpatiumque in Scala repertum per convolutionum numerum dividebam. Unde inventa eſt unius convolutionis latitudo, ſive ipſa Capilli Diameter. Poſtea Capillum eundem, in Segmenta minutula diviſum, plano Microſcopii, cui Sanguinis parum ita erat illitum ut Globuli conſpicerentur diſtincti, ſuperinſpergebam. Ea cum Microſcopio contuerer, reperiebam aliquibus in locis Capilli Segmenta ita commode diſpoſita, ut numerare liceret, quot Globuli Diametro Segmenti opponerentur. Erant autem Segmenta Diametro inæqualia, quod Capillus tenuior verſus extremum fuerit, quam propius a Radice, adeo ut jam 7, vel 8, jam 12, 13ve Globuli tranſverſæ Sectioni Capilli reſponderent. Utroque autem Experimento ſæpius iterato, æſtimavi tandem mediam Capilli Diametrum parte $\frac{1}{\frac{1}{3}\frac{1}{4}}$ unciæ, & Diametrum Globuli Sanguinei parte decima Diametri Capilli, ſive parte $\frac{1}{\frac{1}{3}\frac{1}{4}}$ unciæ.

5. Impetus, quem patitur interna Pulmonum ſuperficies ab Aere exſpirando, minor eſt Motu leniſſimi roris è Cælo decidentis.

Scholium. Neglecta eſt in ſolutione Problematum duorum præcedentium impedimenti conſideratio, quod Aeri ex Pulmone egredienti objicitur ex affrictu laterum Arteriæ Trachææ, ejuſque ramorum; cum id perparvum ſit, neque nullo experimento ſatis accuratè æſtimari poſſe videatur. Nec fuimus admodum ſolliciti de rationibus numerorum exquiſitè ſervandis, cum id unum nobis propoſitum fuerit, ut methodum exponeremus æſtimandi, aliquanto certiùs quam videtur antehac factum, vires eas, quibus agit Aer inter exſpirandum in vaſa ſanguinea ſuperficiem Pulmonis internam perreptantia. Unde dignoſci poteſt, utrum pares ſint hæ vires effectis iſtis producendis, quæ iiſdem à Doctiſſimis quibuſdam Scriptoribus Medicis tribuuntur.

Problema III. Definire impetum Sanguinis in Vena Cava prope dextram Auriculam Cordis; ſive motum Sanguinis per omnes Arterias & Venas fluentis, præter Pulmonares. — *Of the* Motion *of the* Blood, *&c.*

Sit q = Quantitas Sanguinis una Cordis Syſtole in Aortam projecti.
l = Longitudo media ductus integri Arterio-Venoſi, ratione habita ramorum longiorum & breviorum.
t = Temporis ſpatium inter binos Pulſus interceptum.

Inde, per Theorema 3. Caſ. 4. impetus quæſitus $= \frac{q\,l}{t}$.

Hoc eſt, Impetus Sanguinis in Vena Cava æquatur motui molis Sanguineæ, quæ una Syſtole in Aortam projicitur, cujus ea ſit velocitas, qua percurri queat integra Arteriarum & Venarum longitudo, temporis ſpatio inter binos Pulſus intercepto. *Q. E. I.*

Si in Corpore Humano ponantur

q = 2 unciæ *Avoird.*
l = 6 pedes
$t = \frac{3''}{4}$.

Erit impetus Sanguinis in Vena Cava æqualis motui ponderis 12 librarum, quod unciæ unius longitudinem conficiat ſingulis minutis ſecundis; ſeu motui ponderis librarum, quod pari temporis ſpatio percurrat pedem $\frac{1}{2}$. Quæ eſt fere Sanguinis velocitas in Cava fluentis. Ponimus autem, ex dimenſione Viri Doctiſſimi ſupra dicti, Cavæ Sectionem dodrantem eſſe unciæ quadratæ.

Corol. Oriuntur ex hoc Problemata mutatis mutandis omnia Problematis primi Corollaria.

Problema IV. Determinare motum abſolutum Sanguinis in Vena Cava; ſive motum Sanguinis, per omnes Arterias & Venas fluentis præter Pulmonales, ſublata Vaſorum reſiſtentia.

Sit

Sit velocitas Sanguinis Naturalis, ad eam velocitatem qua Sanguis flueret, dempta omni reſiſtentia, ut 1 ad x. Cumque per *Corol.* ſuperioris Problematis & *Corol.* 1. *Probl.* 1. Motus Sanguinis ſit in ratione velocitatis, erit inde motus quæſitus $= \frac{x\,q\,l}{t}$. *Q. E. I.*

Quod ſi proportio per Experimentum à Viro Clariſſimo ſupra laudato inſtitutum inventa, ut veræ propinqua, admittatur, erit $x = 2.5$.

Unde, poſitis iiſdem quæ in ſuperiore ponuntur, motus abſolutus ſanguinis in Vena Cava æquatur motui ponderis 30 librarum, quod minuto ſecundo longitudinem uncialem percurrat; ſive motui ponderis 2 librarum percurrentis eodem tempore pedem $1\frac{1}{4}$. Qua fere velocitate Sanguis, omni reſiſtentia liber, per Cavam deferretur.

Problema V. Motum Sanguinis invenire in Vena Pulmonali prope ſiniſtram Cordis Auriculam; ſive motum totius Sanguinis per Pulmonem fluentis.

Præter notulas in *Probl.* 3. uſurpatas, ſit $\lambda =$ Canalis Arterio-Venoſi Pulmonici media longitudo.

Unde, per *Theor.* 3. *Caſ.* 4. invenitur motus quæſitus $= \frac{q\,\lambda}{t}$.

Hoc eſt, motus Sanguinis per Pulmonem fluentis æqualis eſt motui molis Sanguineæ, quæ unâ Syſtole in Arteriam Pulmonalem projicitur, obtinentis eam velocitatem, qua percurratur longitudo Arteriarum ac Venarum Pulmonalium, tempore inter duos Pulſus intercepto. *Q. E. I.*

Si ponatur in Corpore Humano $\lambda = 1\frac{1}{2}$ pes.

Erit motus Sanguinis in Pulmone æqualis motui ponderis 3 librarum, percurrentis unciale ſpatium minuto ſecundo.

Problema VI. Definire momentum Sanguinis abſolutum in Vena Pulmonali.

Eodem argumento, quod *Probl.* 4. uſurpatum eſt, invenitur motus quæſitus $= 2.5 \times \frac{q\,\lambda}{t}$. *Q. E. I.*

Poſitis verò iiſdem quæ ſupra ponuntur, motus abſolutus Sanguinis Pulmonem præterfluentis æquatur motui ponderis $7\frac{1}{2}$ librarum, quod ſingulis minutis ſecundis unciæ unius ſpatium percurrat.

Scholium. Experimento *Keiliano* definita eſt proportio, quam obtinet Sanguinis per Aortam ejuſque ramos fluentis velocitas naturalis, ad eam velocitatem qua Sanguis per eoſdem flueret, ſublata reſiſtentia Arteriarum & Sanguinis præcedentis. Eam nos proportionem ad Sanguinem per Arteriam Pulmonalem fluentem tranſtulimus. Quia vel ſublata vel imminuta ſecundum quamvis rationem reſiſtentia, quæ Sanguini per utramque Arteriam fluenti objicitur, neceſſariò Sanguis pariter acceleratur in utraque Arteria. Id enim niſi fiat, bini Cordis Ventriculi

triculi aut eodem tempore non contrahentur, aut eandem Sanguinis quantitatem non ejicient. Quorum utrumvis, abſque ſumma totius Machinæ perturbatione & diſcrimine, fieri omnino non poteſt.

Corol. Ad tria Problemata præcedentia.

Sequuntur hinc Corollaria Problemati quinto ſubjuncta, mutatis mutandis.

Scholium ad quatuor Problemata ſuperiora.

Notandum Sanguinis velocitatem, tum per Pulmonem, tum per reliquum Corpus fluentis, cum reipſa æquabilis non ſit, hic tamen talem fingi, ut motus Sanguinis medius inveniatur.

Scholium generale.] Si cui numeri minùs accurati videantur, qui ſparſim Characteribus ſpecioſis apponuntur, poterit ille facili opera, inventis per experimenta numeris qui propiùs ad verum accedant, motuum exempla ſupra poſita, vel Propoſitionum ipſarum Corollariorum ope, corrigere.

The Heſſian *Bellows improv'd, by Mr.* D. Papin. n. 300. p. 1990.

V. I am buſy at preſent for a Coal-mine, which hath been left off becauſe of the Impurity of the Air; I have therefore improved the *Heſſian* Bellows: An Account of that Contrivance is printed *Lipſiæ* in *Actis Eruditorum anno* 1699. with this Title, *Rotatilis Suctor & Preſſor Heſſiacus:* And it may be applied for Wind as well as for Water. At that Time the Shape of the *Tympanum* was Cylindric, as may be ſeen *Fig.* 210. where *D A F C* is the Circumference: *C P*, *D P*, *A P*, are the *Radii* which bear the Wings *C m*, *D n*, *A o*: *C E* is the Aperture through which the Wind muſt be driven in the Direction of the Tangent C B: And it may be obſerved, that when the Engine is working, every Wing from the End of the Aperture *E*, till it comes to the Beginning of the ſame Aperture C, drives always the ſame Air, with the ſame Swiftneſs, and at the ſame Diſtance from the Center: So that in peruſing all that Circumference, the Air doth find Reſiſtance by Friction, and gets nothing at all. I do therefore now make the Circumference of the *Tympanum* in the Spiral Shape, which is to be ſeen *Fig.* 211. where the Spiral Circumference is *A F G B*, the *Radii* are *A P*, *C P*, *D P*, *&c.* The Wings are *A M*, *C N*, *D O*, *&c.* The Aperture is *A B*. And it is to be obſerved, that every Wing in going round drives new Air, becauſe the Air which is firſt in Motion finds Place to recede from the Centre towards the Spiral Circumference; and ſo it gives room to new Air to come to the Wing: And when the Wings come near to the Aperture, they drive their new Air into the Apertture without any Friction; and the Air which hath been firſt driven and removed from the Wing, cannot loſe its Swiftneſs, becauſe the Wings which continually follow do continually drive new Air, which keeps that which is before always in the ſame Swiftneſs. This new Shape of the *Heſſian* Bellows affords alſo another Advantage; becauſe the Air in going round follows the Spiral-line, which is nearer to the ſtrait Line than a circular Circumference; and when the

Fig. 210.

Fig. 211.

the Air comes to the Aperture, it gets into it without any Loſs of Subſtance; but in the Cylindrical Machine, the Air doth always go round in a circular Circumference, and when it comes to the Aperture, the Wind is driven directly in the Direction of the Tangent, but juſt in the Beginning at C; and afterwards the Impulſion is oblique: And this Obliquity is always increaſing until the Wing comes to the *punctum A:* Now it is known how much Diminution ſuch an Obliquity can make to the Strength. I believe therefore that this Spiral Figure is a good Improvement to this Engine. And indeed I have made ſuch Bellows, where the *Radius A P* is but 10 $\frac{1}{2}$ Inches, the Wing *A m* 2 Inches broad and 9 Inches high; becauſe the *Tympanum* is alſo ſo high, or little more; the Aperture *A B* is alſo 9 Inches, or a little more, ſo that it makes a ſquare Hole. When I work this Engine with my Foot, it makes ſuch a Wind, that it may raiſe up two Pounds Weight; and without doubt, a ſtronger Man could do much more: But this is more than ſufficient for our Purpoſe, ſince we muſt but drive Air enough for the Reſpiration of ſuch Men that can work in the Mine; and we may eaſily with Boards make wooden Pipes, to carry the Wind to the very Bottom: So that the Air within will be continually renewed as well as without.

As to the Engine to demonſtrate the Power of Water expanded by Fire, we have here made very good Experiments of that Matter before Winter. We have raiſed Water to the height of 70 Foot, by a very commodious Way, which may be yet very much improved. The *Heſſian* Bellows may be very uſeful to a Furnace, I have already made a little Trial of it, and I had a very ſtrong Fire in a Furnace, to melt Glaſs, Iron, or any other hard Metal; and yet I could open the Furnace above the Matter to be wrought upon, and yet no Flame would get out through the Aperture; nor cold Air from without get into the Furnace: So that it is very like this will be a great Conveniency for ſeveral ſorts of Work, ſince Men may work the Matters when they are moſt ſoftened in the Fire; and they may be drawn up perpendicularly, that they may not be bent, as they are when we draw them Horizontally. I believe that would be good, eſpecially to make eaſily Glaſs Pipes and Looking-Glaſſes of an extraordinary Bigneſs.

VI. *Account of a Book omitted.*

Joannis Poleni in Gymnaſio *Patavino* Phil. Ord. Prof. & Scient. Societatum Regalium, quæ *Londini* & *Berolini* ſunt, Sodalis, *De Motu Aquæ Mixto*, Libri Duo, *&c.* 4*to.* *Patavii* 1717.

CHAP.

CHAP. VI.

Geography. Navigation.

I. SEveral Perſons have given us, as they have ſuppoſed, the juſt Number of Acres contained in *England*, or *South Britain*, or very near it. Sir *William Petty* reckons about 28 Millions; Others, 29 Millions; others, a few more. But they have all been miſtaken in under-reckoning. *A Demonſtration of the* Number *of* Acres *in* England, *by Dr.* N. Grew. n. 330. p. 266.

And the Reaſon of their Miſtakes ſeems to have been, their reckoning only by the Maps; that is, by computed, and not by meaſured Miles; by which only the Number of Acres can be known.

I have ſeen an Account of the Number of Acres in each County: Which Account, whether taken from Doomſday-Book, or from any other Regiſter, cannot be true. For tho' we have loſt ſome Land, yet there is a great deal more now gained, which in the Conqueror's Time lay under Sea. Within 120 Years, very much has been recovered out of the Seas, and maintained by Banks, in the Marſhes and Fenns of *Eſſex*, *Kent*, and the Iſle of *Ely*. And in ſome Parts of *Lincolnſhire*, the Land has gained of the Sea, 4 Miles in a direct Line from Land to Sea, in the Memory of Men now Living.

Nor is it the truer, for having been taken from any other Record: For if the Numbers of Acres, according to the ſaid Account, in each Shire, be put together, they exceed not 39 Millions and a Quarter: Which Number, though it comes much nearer to the Truth than any of the former, yet is a great deal ſhort of it.

For however, according to vulgar Computation, *England*, or *South Britain*, is reckoned in length but 305 Miles; and in breadth, about 290 Miles: Nevertheleſs, it appears by an exact Wheel-Meaſure, That from *New-Haven* in the *South* of *England* to *London*, are 56 meaſured Miles; and that from thence by a ſtrait Line continued to *Berwick* in the *North*, are 339 of the ſame meaſured Miles; in all 395 meaſured Miles, the true length of *England*. And again, that from the *South* Foreland in the *Eaſt*, to the Land's End in *Cornwall*, are about 367 Miles of the ſame Wheel-meaſure, the true Breadth of *England*.

This being known, it is eaſy to know alſo, how many ſquare Miles and conſequently how many Acres are contained in *England*, or *South Britain*.

If a Line be drawn on a Chart of *England*, from the *South* Foreland in *Kent* to *Berwick*; and from the two Ends of this Line, two more

Lines meeting at the Land's End in *Cornwal*, they will make the Triangle *A B C*: Which Triangle, as it excludes as much more of the Land, as it includes of the Sea, as may anſwer the ſmall Number of Miles obtained by the Curvity of the Roads; it may therefore be allowed to be equal to the *Area* of *England*, or *South Britain*.

Fig. 212.

Next, if to the Triangle *A B C*, another Similar and Equal Triangle *B C D*, be added; both together make the Rhomboid *A B D C*. Which being divided at *E F*, maketh the Rhomboids *A C E F*, and *B D E F*, equal to one another. One of which is therefore equal to the Triangle *A B C*. And the Rectangle *A G H F*, ſtanding upon the ſame Baſe, and between the ſame Parallel Lines with the Rhomboid *A C E F*, by the 35*th* of the 1*ſt* of *Euclid*, is equal to the ſaid *A C E F*; equal to the Triangle *A B C*; equal to the *Area* of *England*, or *South Britain*.

Now the Length between *Berwick* and the South Foreland in *Kent*, being about 5 Miles more than between *Berwick* and *New-Haven*, which is 395 Miles: Therefore the Line *A B*, may be taken for 400 Miles; and ſo the Line *A F*, for 200. And the Line *A G* being leſs by about 7 Miles, than between the South Foreland in *Kent*, and the Land's End in *Cornwall*, which is 367 Miles, the ſaid *A G*, may be taken for 360 Miles. Therefore *A G*, 360, being multiply'd by *A F*, 200, produceth 72000 Square Miles: And 72000 being multiplied by 640, the Number of Acres contained in one Square Mile, produceth 46 Millions and 80000, the Number of Acres contained in *England*, or *South Britain*.

Whence it appears, Firſt, that if the Province of *Holland* contains, as is computed, but one Million of Acres, then *England* is more, by a Fraction of 80000 Acres, than 46 Times as big as *Holland*.

Next, if in the Province of *Holland*, containing but one Million of Acres, are two Millions and 400 Thouſand Souls, or two Millions and four 10*ths*, as they are ſaid to be; then *England*, which contains 46 Millions of Acres, to be proportionably populous, ſhould have twice 46 Millions of People, and four 10*th's* of 46; that is, about 110 Millions.

But to allow room enough for Perſons of all Degrees, if *England* were half as populous as *Holland*, with only 55 Millions, it were a good Proportion, and would be near 5 Times our preſent Number: And about 22 Times as many as in the Province of *Holland*.

To people *England* in a competent Time, with this Number, there are many Ways practicable: By which, I have computed, the preſent Number may be doubled in 24 or 25 Years. And probably quadrupled in about 36 Years.

One of theſe Ways, though not the ſpeedieſt, would be the introducing of Strangers: Yet to make uſe of this, or of any other Way, to multiply the People, before we have provided the Means of employing them, would be prepoſterous.

But

But when we ſhall mind our true Intereſt, in employing and encouraging every where our own Hands, and the Hands of other Nations, as the *French* and *Dutch* do, in all the ſorts of Huſbandry, Manufactury, and Merchantry: When our Nobility and Gentry themſelves, ſhall be Examples in ſome or other of theſe Particulars: When we ſhall hereby be univerſally engag'd to incloſe, and to improve every Foot of our Land; to make the utmoſt Uſe of all our Home Growths, above and under Ground; and of all our Ports, (about 200 great and ſmall,) more than in all the Kingdoms and States of *Europe* put together: And when *Scotland* and *Ireland* ſhall both of them afterwards be improved in like Manner; when all Mens Heads and Hands ſhall be thus employ'd about ſome one honeſt and profitable Buſineſs, it is eaſy to foreſee how highly it will advance the *Britiſh* Monarchy and People, at Home, and all over the World, in Beauty, Strength and Glory.

II. I conclude that the Eclipſe of the Moon of *Dec.* 12*th* 1703. began at *London* at about 31 or 32 Minutes after 4 in the Morning.

The Difference of Longitude *between* London *and* Cambridge *in* New England, *by Mr.* J. Hodgſon. n. 292. p. 1637.

At *Cambridge*, about 4 Miles from *Boſton* in *New England*, Mr. *Brattle* found, † that at 44 Minutes after 11 at Night, part of the Moon's Diſk looked ſomewhat duſkiſh, and that at 52 Minutes, the Shadow was well enter'd: So that from hence, as well as from a Compariſon of the Ingreſs and Egreſs of the principal Spots, it probably began there about 49 Minutes after 11; whence it follows, that *Cambridge* in *New England* lies $4^h\ 4'\ 2\frac{1}{2}$, or 70 37′, to the Weſtward of the Meridian of *London*.

† *Vid.* ſupra p. 271.

III. 'Tis now above thirty Years, ſince I had a Diſpute with ſome of the *French Geographers* about the Longitude of the Cape of *Good Hope*, ſaid to have been obſerv'd by the Religious Miſſionaries ſent to *China* in the Year 1685. By an Emerſion of the firſt Satellite of *Jupiter*, they determined that Cape to be $1^h\ 11'$, or $17\frac{3}{4}$ *gr.* more Eaſterly than *Paris*; that is, 20 *gr.* from *London*: Which, for the Reaſons I then gave, ‖ I concluded could not be more than 17 *gr.* Very lately I have fallen upon an Obſervation which I believe will determine the Controverſy in my Favour; for I had accidentally a Journal of an Officer of the Ship *Emperor*, put into my Hands, who in his return from *India*, on the fifth of *March* 1718. obſerv'd the End of a Lunar Eclipſe, when the viſible Altitude of the Moon's Center was 13° 25, he being then in the Latitude of 34° 23′ *South*, and as they found afterwards, juſt 180 Leagues to the Eaſtwards of Cape *Bonne Eſperance*. By Calculation I find, that in that Latitude, the Moon had that height at $7^h\ 17'\ \frac{1}{2}$ *P. M.* and by comparing this Eclipſe with that we obſerv'd with great Exactneſs on *Feb.* 11°, 1682. (which agrees perfectly well with our Numbers) I conclude the middle of this to have happen'd at *London* at $3^h\ 48'$ *P. M.* to which adding $1^h\ 46'$ for the Semiduration (this being very certain from the obſerved Continuance of the Eclipſe of 1682.)

The Longitude *of the* Cape *of* Good Hope, *&c. by Dr.* E. Halley. n. 361. p. 992.

‖ *Vid.* Supra V. I. C. VII. S. XXVI.

the End will be found to have been at *London* at 5^h 34′. The Ship was therefore in a Meridian 26° to the Eaſtwards of *London*: But ſhe was at that Time 180 Leagues to the Eaſtwards of the *Cape*, which Diſtance in that Latitude, gives eleven Degrees of Longitude; this therefore being deducted from the Longitude of the Ship, leaves juſt 15 *gr.* or one Hour, for the Difference of Meridians between *London* and the *Cape*. So that by this Account, the *Cape* is yet nearer our Meridian than I had formerly plac'd it, and near ſix Degrees nearer than M. *De la Hire* places it in his Tables.

This Eclipſe was attended with all the Circumſtances requiſite to make the Concluſion as certain as the Nature of the Thing will admit of: For the Moon was nearly *in Perigæo*, and the Eclipſe almoſt central; ſo that ſhe emerged out of the Shadow as ſwiftly as poſſible. The Sea was very ſmooth, there having been little Wind for above 30 Hours before; and the Moon was not too high to be well obſerved with a Foreſtaff: Nor were they long at Sea, before they made the Land; for in leſs than five Days, on the tenth of *March*, at Noon, they had paſt Cape *d'Agulhas*, the moſt Southerly Promontory of *Africa*, which then bore from them *North Eaſt*, about ſeven Leagues diſtant. The End of this Eclipſe, though not viſible here, might have been ſeen in *Germany*, both at *Nurenburg*, *Leipſick* and *Berlin*; but we do not hear that it was any where obſerved there: However, our Numbers in this Caſe may be ſecurely relied on.

On this Occaſion, I ſhall inſert an Obſervation or two I procured to be made at the *Cape*, by Mr. *Alexander Brown*, a *Scotch* Gentleman. He carried with him a very good *Braſs Quadrant* of above two Foot Radius, and at the *Dutch* Settlement at *Table Bay*, having rectify'd his *Pendulum Clock* by correſpondent Altitudes, on the 4*th* of *Auguſt* 1694. at 5^h 59′ *Manè*, the Diſtance of the bright Limb of the Moon from the Right Shoulder of *Orion*, was obſerv'd to be 25° 3′. And the next Morning *Aug.* 5. at 5^h 21′ 12″, the ſame Limb was diſtant from *Procyon* 25° 57′, and at 5^h 36′ 48″ from the *Lucida Arietis* 58° 29′.

It were much to be wiſh'd, that the Moon had, either of theſe Mornings, been obſerv'd at *Greenwich* or *Paris*, or at ſome Place in *Europe* whoſe Longitude from them is well known: But that failing us, I had recourſe to the Period of the Lunar Motions, which is perform'd in 18 Years and ten or eleven Days; after which, the Errors of our Lunar Computations return very nearly the ſame; and I found among my own old Obſervations, one that agreed well with that of the 4*th* of *Auguſt*, *viz.* Anno 1676. *July* 23° 13^h 11′ 35″ at *Oxford*, I obſerv'd the Moon to apply to the Star *in medio Collo Tauri*, by *Bayer* mark'd *A*. The Star at that Time was diſtant from the Southern and neareſt Cuſp of the Moon, by the Micrometer 20′ 32″, and at 13^h 17′ 15″, when it ſeem'd to immerge upon the bright Limb of the Moon, it was diſtant from the Northern Cuſp 23′ 20″; but this is leſs certain, by reaſon of the hazy Air. The Star at that

that time was in ♉ 28° 56′. with 1° 13′ 20″. *North* Lat. whereby I found, that our Lunar Tables, founded on Sir *Iſaac Newton*'s Theory of her Motion, gave her Place at that Time only two Minutes too ſlow; which Error being allowed on the 4*th* of *Auguſt* 1694. the reſult was, that 5^h 59′. at Cape *Bonne Eſperance*, was at *London* 4^h 53′. whence the Difference of Longitude 16 $\frac{1}{2}$ Degrees, ſufficiently near what we had before determin'd.

IV. The Gentlemen of the *Royal Academy of Sciences* in *France*, have, for ſome Years paſt, apply'd themſelves with much Candour and Diligence, to examine the Chart I publiſh'd in the Year 1701. for ſhewing at one View the Variations of the Magnetical Compaſs, in all thoſe Seas with which the *Engliſh* Navigators are acquainted; and I find, that what I did ſo long ago, has been ſince abundantly verified by the concurrent Reports of the *French* Pilots, who of late have had frequent Opportunities of inquiring into the Truth thereof. So that I am in Hopes, I have laid a ſure Foundation for the future Diſcovery of the Law or Rule by which the ſaid Variations change, in Appearance regularly, all the World over. Of this I have long ſince given my Thoughts, † and as yet I ſee no Cauſe to retract what I there offer for a Reaſon of this Change; but of this we might be more certain, had we a good Collection of Obſervations made in that Ocean, which divides *Aſia* and *America*, and occupies about two Fifths of the whole Circumference of the Globe. This, we hope, may be effectually ſupply'd by the *French*, who may return from *Peru* by the *Eaſt Indies*.

Of the Variation *at* Paraiba, *&c. And the* Longitude *of the* Magellan Straights, *&c. by Dr.* E. Halley. n. 341. p. 165.

† *Vid.* Supra V. II. C. IV. S. VIII.

In the mean time I cannot omit to take Notice of two Particulars, ſeeming to call in Queſtion the Truth of my aforeſaid Map, in the *Memoirs* of the *Royal Academy of Sciences*.

The one is in the *Memoirs* of the Year 1700. concerning the Variation obſerved at *Paraiba* in *Brazile*, about 25 Leagues to the Northwards of *Pernambouc*, by M. *Couplet le fils*, whoſe Words are theſe:

Of the Variation *at* Paraiba *in* Brazile.

Le 20 *Mai*, 1698. *ayant auparavant tracé ſeigneuſement une ligne* Meridienne, *dont je m'etois ſervi pour les Obſervations Aſtronomiques, j'obſervai la declination de l'aiguille aimantée de* 5° 35′. Nordoueſt. And the ſame Obſerver tells us, that he found the Latitude of the Town of *Paraiba* 6° 38′ 18″. Now it happen'd, that I was in the River of *Paraiba*, in *March* 1699. and there fitted and clean'd my Ship; ſo that I had full Opportunity to obſerve the Variation both on Board and on Shore, and found it conſtantly to be above 4 *gr. North Eaſt*; ſo that I am willing to believe this to be an Error of the Preſs, putting N. W. for N. E. or rather of the Memory of M. *Couplet*, who, it ſeems, loſt all his Papers by Shipwreck in his Return. The ſame may be ſaid of the Latitude of *Paraiba*, which, though I did not obſerve my ſelf, yet at the Fort of *Cabo Dello*, at the Mouth of the River, and which is about 3 Leagues more Northerly than the Town, I found the Latitude not

leſs

leſs than 6° 55′ South, and by Conſequence that of the Town more than 7 Degrees.

The other is in a Diſcourſe of M. *de Liſle*, in the *Memoirs* of 1710; where he compares the Variations obſerved in ſome late Voyages, with my Map of the Variations. Among other Things, 'tis there ſaid, that on the Eaſt-ſide of the Iſland St. *Thomas*, under the Equinoctial Line, M. *Bigot de la Canté*, had, in the beginning of the Year 1708, found the Variation 11½ *gr.* whereas my Chart makes it but 5½ *gr.* I never indeed obſerved my ſelf in thoſe Parts; and 'tis from the Accounts of others, and the Analogy of the whole, that in ſuch Caſes I was forc'd to ſupply what was wanting; and 'tis poſſible, that there may be more Variation on that Coaſt than I have allowed. But conſulting my Chart, (which was fitted to the Year 1700,) I find I then make the Variation at the Iſle of St. *Thomas*, full 7½ *gr.* and not 5½ *gr.* the which, by the Year 1708, might well ariſe to near 9 *gr.* So that the Difference will become very tolerable; whereas an Error of 6 *gr.* ſuch as is here repreſented, would render the Credit of my Chart juſtly ſuſpected.

Of the Longitude *of the* Magellan *Straights.*

But a further Thing I might complain of, is, that in the ſame *Memoir* of M. *de Liſle*, the *Geography* of my Chart is called in Queſtion; and we are told, that I have placed the Entrance of the *Magellan* Straights at leaſt 10 Degrees more Weſterly than I ought to have done: For that the Ship St. *Louis*, in the Year 1708, ſailing from the Mouth of *Rio Gallega*, in about the Latitude of 52 *gr.* South, and not far from Cape *Virgin*, directly for Cape *Bonne Eſperance* (which Courſe perhaps was never run before) had found the Diſtance between the two Lands not more than 1350 Leagues, which, he concludes, is much leſs than my Chart of the Variation makes it. I know not from what Computation M. *de Liſle* has drawn this Conſequence; but I find by my Chart, that I have made the Longitude of *Rio Gallega* 75 *gr.* Weſt from *London*, and that of Cape *Bonne Eſperance* 16 ½ Eaſt from it; that is in all 91½ *gr.* difference of Longitude. This, with the two Latitudes, gives the Diſtance, according to the Rhumb-line, 1364 Leagues; but according to the Arch of a great Circle, no more than 1287 Leagues. So that inſtead of invalidating what I have there laid down, it does abſolutely confirm it, as far as the Authority of one ſingle Ship's Journals can do it.

I do not pretend, that I have had Obſervations made with all the Preciſion requiſite, to lay down inconteſtably the *Magellan* Straights in their true Geographical Site; but it has not been without good Grounds, that I have placed them, as I have done. For when Sir *John Narborough*, in the Year 1670, wintered in Port St. *Julian*, on the Coaſt of *Patagonia*, Capt. *John Wood*, then his Lieutenant, and an approved Artiſt in Sea-Affairs, did obſerve the beginning of an Eclipſe of the Moon, *Sept.* 18. *Stil. vet.* at juſt 8 at Night: And the ſame beginning was obſerv'd by M. *Hevelius* at *Dantzick*, at 14ʰ 22′; whence

Port St. *Julian* is more Westerly than *Dantzick* 6^h 22′, or than *London* 5^h 6, that is 76 ½ *gr.* Besides, I have had in my Custody a very curious Journal of Capt. *Strong*, who went into the *South Seas* in quest of a Plate-wreck, and who discover'd the two Islands he called *Falkland*'s *Isles*, lying about 120 Leagues to the Eastwards of the *Patagon* Coast, about the Lat. of 51 ½. This Capt. *Strong* had a quick Passage from the Island of *Trinidada* (in 20 ½ South) to the *Magellan* Straights; and in this Journal, which was very well kept, I found, that Cape *Virgin* was, by his Account, 45 Degrees of Longitude more Westerly than that Island, whose Longitude I know to be just 30 Degrees from *London*; that is in all, 75 *gr.*

From these concurrent Testimonies, I adventured to fix the Longitude of this Coast as I have done; and I can by no Means grant an Error of 10 Degrees to be possible in it, though perhaps it may need some smaller Correction. I will however readily grant, that those that go thither from *Europe*, shall find the Land more Easterly than is here expres's'd, by reason of a constant Current setting to the Westward near the Equator, where Ships are many Times long detained by Calms, whilst the Stream carries them along with it; which Thing befals all Ships bound to any Part of the East Coast of the *South America*.

Variation.			Latitude.			Longit. from *London*.		
8°	32′	West.	49°	18′	North.	07°	29′	West.
6	42		44	31		13	45	
5	30		41	06		15	08	
5	04		40	22		14	54	
4	22		39	11		15	35	
3	30		32	21		15	39	
3	35		32	42		15	38	
1	20		18	50		20	52	
1	14		09	26		17	59	
1	10		00	49		18	42	
1	00		01	09	South.	18	58	
0	16		02	32		19	48	
0	00		03	17		20	05	
0	40	East.	03	58		20	27	
1	02		05	09		21	39	
1	30		06	21		22	08	
1	50		08	03		23	15	
2	10		09	07		23	35	
3	32		12	03		25	03	
6	04		18	53		26	30	
6	19		19	51		27	02	

V. *The* Variation *of the* Compass *in the* Atlantic *and* Æthiopic *Oceans*. A. D. 1706. *by Mr.* J. Maxwell. n. 310. p. 2433.

Variation

Variation.			Latitude.			Longit. from *London*.		
6°	20′	East.	21°	26′	South.	28°	14′	West..
6	30		21	48		28	10	
7	00		21	58		28	23	
6	45		24	45		27	56	
6	36		27	11		27	17	
5	04		33	53		16	58	
0	00		34	21		01	29	30″
1	00	West.	34	15		01	33	East.
4	16		33	41		06	23	
8	46		34	39		13	02	
11	56		34	30		16	15	*at the Cape of*
11	30		32	51		13	41	Good Hope.
10	00		30	21		11	46	
09	44		29	51		11	44	
09	34		29	28		11	31	
09	22		28	56		11	05	
09	04		27	38		10	01	
08	30		26	55		08	45	
08	02		25	41		07	22	
07	32		24	32		05	43	
01	52		16	00		06	30	West *at the Isle of St.* Helena.

A Mechanical Way to Divide *the* Nautical Meridian Line *in* Mercator's *Projection. And the* Relation *of that* Line *to the* Curva Catenaria, *by Mr.* J. Perks. n. 345. p. 331.

VI. The moſt uſeful Projection of the Spheric Surface of Earth, and Sea for Navigation, is that commonly call'd *Mercator's*; tho' it's true Nature and Conſtruction is ſaid to be firſt demonſtrated by Mr. *Wright*, in his *Correction of the Errors in Navigation.* In this Projection the Meridians are all parallel Lines, not divided *equally*, as in the common plain Chart (which is therefore erroneous) but the Minutes and Degrees (or ſtrictly, the *Fluxions of the Meridian*) at every ſeveral Latitude are proportional to their reſpective *Secants*. Or a Degree in the projected Meridian at any Latitude, is to a Degree of Longitude in the Equator, as the *Secant* of the ſame Latitude is to *Radius*.

The Reaſon of which Enlargement of the Elements of Latitude is, to counterbalance the Enlargement of the Degrees of Longitude. For in this Projection, the Meridians being all parallel, a Degree of Longitude at (ſuppoſe) 60 Deg. Lat. is become equal to a Degree in the Equator, whereas it really is (on the Globe's Surface) but *half* as much, the Radius of the Parallel of 60 Deg. (that is its *Coſine*) being but *half* the Radius of the Equator. Therefore to proportion the Degrees of Latitude to thoſe of Longitude, a Degree (or Elemental Particle)

ticle) in the Meridian, is to be as much greater than a Degree (or like Particle) in the Equator, as the Radius of the Equator is greater than the Radius of the Parallel of Latitude, *viz.* its *Cosine.*

Let the Radius CD represent half of the Equator, DM an Arc of the Meridian; MS its Sine, CE its Secant; then is CS equal to its *Cosine*: and $CS : CM :: CD (=CM) : CE$, that is, as Cosine : to Radius :: so is Radius : to Secant. The Cosines being then, in this Projection, suppos'd all equal to Radius, or (which comes to the same) the Parallels of Latitude being all made equal to the Equator, the Radius of the Globe, at every Point of Latitude, (by the precedent Analogy) is supposed equal to the Secant of Latitude; and consequently the Elements (Minutes, *&c.*) of the Meridian must be proportional to their respective Secants. Fig. 214.

The Way Mr. *Wright* takes for making his Table of *Meridional Parts*, is by a continual Addition of Natural Secants, beginning at 1 Minute, and so proceeding to 89 Deg. Dr. *Wallis* (in *Phil. Trans.* N°. 176.) finds the Meridional Part belonging to any Latitude by this *Series*, putting S for its Natural Sine, *viz.* $S + \frac{1}{3}S^3 + \frac{1}{5}S^5 + \frac{1}{7}S^7 + \frac{1}{9}S^9$ &c. which gives the *Merid. Part* required. How to find the same mechanically by Means of an easily constructed Curve Line, is what I shall now shew.

1. Prepare a Rular AB of a convenient Length, in which let Bo be equal to the Radius of the intended Projection. To the Point o as a Center (on the narrower Edge of the Rular) fasten a little Plate-Wheel wh tight to the Rular, and of a Diameter a little more than the Thickness of the Rular. Let KR (*Fig.* 214.) represent another long Rular, to which AR is a perpendicular Line. Place the Rular AB upon the Line AR, with the Center of the Wheel at A. Then with one Hand holding fast the Rular KR, with the other Hand slide the End B of the Rular AB by the Edge of KR; so will the little Wheel wh describe on the Paper a Curve Line ACB, to be continued, as far as is convenient. Fig. 213. Fig. 214.

2. Having drawn the Curve ACB, draw a strait Line KR by the Edge of the Rular KR: which Line is the Meridian to be divided, and also an Asymptote to the Curve ACB.

3. In this Meridian, (accounting R to be the Point of its Intersection with the Equator,) the Point answering to any Degree of Latitude is thus found. In the perpendicular AR, make RG equal to the *Cosine* of Latitude (Radius being AR,) and from G draw GC parallel to KR, and intersecting the Curve in C. With Center C and Radius $CM = AR$, strike an Arc, cutting the Meridian at M; so is M the Point desir'd.

4. In the Curve AC, let c be a Point infinitely near to C, and cm, $(=CM,)$ a Tangent to the Curve at c, making the little Angle MCm, to which let the Angle RAr be equal: So is $Rr = Md$ (a Perpendicular from M to cm.) Draw CD equal and parallel to AR, intersecting

KR in S. With Center C and Radius CD draw the Arc DM, and its Tangent DE and Secant CE.

5. Becauſe of the like Triangles CDE, Mdm; $CD : CE :: MD : Mm$, that is, as Radius to Secant of the Arc DM, (whoſe Coſine is $CS = GR$,) :: ſo is Md ($= Rr$ a Degree or Particle of the Equator :) to Mm the Fluxion or correſpondent Particle of the Meridian Line RM. Whence, and from what is premiſed concerning the Nature of this Nautical Projection, 'tis evident, that RM is the *meridional Part*, anſwering to the Latitude whoſe Coſine is GR. Or thus; With Center R and Radius AR deſcribe the Quadrant $A \varkappa \alpha$, in which let the Arc $A \varkappa$ be equal to the given Lat. From $\varkappa$ draw $\varkappa C$ parallel to KR, and interſecting the Curve in C, ſo is $C \varkappa$ the Meridional Part deſir'd, being equal to RM, as is eaſy to ſhew.

6. As to the other Properties of this Curve, 'tis evident, from its Conſtruction, that its *Tangent* (as CM) is a *Conſtant Line* every where equal to AR; the Curve being generated by the Motion of the Wheel at the End of the Rular which is its Tangent. And from hence the Curve ACB may, for Diſtinction, be call'd the *Equitangential Curve*.

7. The Fluxion of the Area $ARMC$ is the little Sector or Triangle MCd, which ſame is alſo the Fluxion of the Sector CDM: whence the Areas $ARMC$, CDM are equal, and the whole Area ACB, &c. KMR being infinitely continued, is equal to the Quadrant $AR\alpha$.

8. To find the Radius of Curvature of any Particle, as Cc, from C draw an indefinite Line $C\mathcal{T}$ perpendicular to CM, (on the Concave ſide of the Curve) and from c another Line perpendicular to cm, which Lines, (becauſe of the Inclination of CM to cm) will ſomewhere meet as at $\mathcal{T}$, making an Angle $C\mathcal{T}c = MCm$. Theſe Angles being equal, their Radii are proportional to their Arcs: therefore, $Md : Cc :: MC : C\mathcal{T}$. But $Cc = dm$ (becauſe of $CM = cm$) ſo that $Md : dm$ (:: $CD : DE$) :: $CM : C\mathcal{T}$. But $CD = CM$, therefore $C\mathcal{T} = DE =$ Tangent of the Arc DM.

9. So that ſuppoſing $A\mathcal{T}t$ a Curve Line, in which are all the Centers of Curvature of the Particles of ACB, any Point as $\mathcal{T}$ being found as before, the Length $A\mathcal{T}$ (by the Nature of *Evolution of Curves*,) is every where equal to the *Tangent* of its correſpondent circular Arc DM. The Point $\mathcal{T}$ is alſo found by making $M\mathcal{T}$ perpendicular to RM, and equal to the Secant CE: for ſo is the Angle $CM\mathcal{T} = MCD$; and the Triangle $MC\mathcal{T}$ equal to the Triangle CDE.

10. Let AHb be an Equilateral Hyperbola, whoſe Semiaxis is AR and Center R. In the Meridian let RP be equal to the Tangent DE. Join AP, and draw $PH = AP$ and parallel to AR. Compleat the Parallelogram $HNRP$, ſo will the Point H be in the Hyperbola, and its ordinate HN ($= RP = DE = C\mathcal{T}$) be equal to the Curve $A\mathcal{T}t$. From whence, and from *Prop.* 3. *Coroll.* 2. of Dr. *Gregory*'s *Catenaria* (*Phil. Tranſ.* N° 231. †) it appears, that the Curve $A\mathcal{T}t$ is that called the

† *Vid.* Supra. V. I. C. I. S. XIII.

he *Catenaria* or *Funicularia*, *viz.* the Curve, into whoſe Figure a *ſlack Cord or Chain* naturally diſpoſes its ſelf by the Gravity of its Particles.

" 11. Hence we have another Property of the *Catenaria* not hitherto " taken Notice of (that I know of) *viz.* that ſuppoſing AR ($=a$, the " conſtant Line in Dr. *Gregory*) equal to the *Radius* of the Nautical " Projection, and RN the Secant of a given Latitude, then is $N\mathcal{T}$ the " *Catenaria*'s Ordinate at N, equal to RM the Meridional Part anſwer- " ing to the Latitude, whoſe Secant is RN.

12. That $\mathcal{T}A$ is the *Catenaria* is alſo demonſtrable from Dr. *Gregory*'s firſt *Prop.* Let $\mathcal{T}u$ be the Fluxion of the Ordinate $N\mathcal{T}$: and tu ($=Nn$) the Fluxion of the Axe AN. Then becauſe of like Triangles $\mathcal{T}CM$, $\mathcal{T}ut$, $CM : C\mathcal{T}$ ($=\mathcal{T}A$) :: $\mathcal{T}u : ut$, that is, as CM a conſtant Line is to $\mathcal{T}A$ the Curve :: ſo is the Fluxion of the Ordinate to that of the Axe ($\dot{y} : \dot{x}$) according to *Prop.* 1. *Catenariæ*.

13. From the Premiſſes the Conſtruction and ſeveral Properties of the *Catenaria* are eaſily deducible; one or two of which I'll ſet down.

The Area $A\mathcal{T}MR$ is equal to $AOPR$ a Rectangle contained by Radius AR, and RP the Tangent anſwering to Secant $HP = \mathcal{T}M$. For becauſe of the like Triangles CMm, CEe; $CM : CE :: Mm : Ee$, (that is, putting r, s, t, m for Radius, Secant, Tangent and Meridional Part RM) $r : s :: \dot{m} : \dot{t}$ whence $r\dot{t} = s\dot{m}$, and all the $r\dot{t}$ = all the $s\dot{m}$, that is $AOPR = A\mathcal{T}MR$, which agrees with Dr. *Gregory*'s *Cor.* 5. of *Prop.* 7.

14. Suppoſing the former Conſtruction, let be added the Line RH, including the *Hyperbolic Sector* ARH. I ſay the ſame Sector is equal to half the Rectangle $ARM\mathcal{Q}$ contained by Radius AR and the Meridional Part RM, ($=\frac{1}{2}rm$) For the Sector ARH = Triangle RNH wanting the Semiſegment ANH, The Fluxion of the Triangle RNH is $\frac{s\dot{t}+t\dot{s}}{2}$. The Fluxion of ANH is $t\dot{s}$. So the Fluxion of the Sector ARH is $\frac{s\dot{t}+t\dot{s}}{2} - t\dot{s} = \frac{s\dot{t}-t\dot{s}}{2}$. 'Tis found before (*Sect.* 13.) that $r : s$ ($s : \frac{ss}{r}$) :: $\dot{m} : \dot{t}$; whence $s\dot{t} = \frac{ss}{r}\dot{m}$. And becauſe of the like Triangles CDE, Efe, $CD : DE :: Ef : fe$. But $Ef = Mm = \dot{m}$, becauſe both Ef and Mm are to Md in the ſame Reaſon, *viz.* as s to r; therefore $r : t$ ($t : \frac{tt}{r}$) :: $\dot{m} : \dot{s}$: whence $t\dot{s} = \frac{tt}{r}\dot{m}$, and $\frac{s\dot{t}-t\dot{s}}{2} = \frac{ss-tt}{2r}\dot{m} = \frac{rr}{2r}\dot{m} = \frac{1}{2}r\dot{m}$, = the Fluxion of the hyperbolic

Sector ARH, whose flowing Quantity is therefore equal to $\frac{1}{2} r m = \frac{1}{2} ARM2$, *Q. E. D.*

15. This shews another Property of the *Catenaria*, *viz.* that it squares the Hyperbola; for RM is equal to NT the Ordinate of the *Catenaria*.

Fig. 215. 16. Let AR be Radius, ACB the Equitangential Curve; MRN its Asymptote, in which let M, N, be any two Points equally distant from R. Upon M draw ML parallel to AR and equal to the *Difference* of the Secant and Tangent of that Latitude, whose Meridional Part is RM (by *Sect.* 3, 4.) Upon N draw NO parallel to AR, and equal to the *Sum* of the foresaid Secant and Tangent. Do thus from as many Points in the Asymptote, as is convenient, and a Curve drawn equably through the Points L——A——O, &c. will be a *Logarithmic Curve*, whose *Subtangent* (being constant) is equal to Radius AR.

17. Let no be an Ordinate infinitely near and parallel to NO. $Op = Nn$ the Fluxion of the Asymptote; OT the Tangent, and TN the Subtangent to the Logarith. Curve in O. Then $op : pO :: ON : NT$. But $ON = s + t$, therefore $op = \dot{s} + \dot{t}$. $pO = \dot{m}$ (the Fluxion of the Meridian or Asymptote.) So the Analogy is $\dot{s} + \dot{t} : \dot{m} :: s + t : NT$. By *Sect.* 13, 14. $\dot{s} : \dot{m} :: t : r$. also. $\dot{t} : \dot{m} :: s : r$. and thence $\dot{s} + \dot{t} : \dot{m} :: t + s : r$. wherefore is NT (the Subtangent to LAO) equal to Radius AR a constant Line, and consequently the Curve LAO is the Logarithmic Curve, and its Subtangent known.

18. The same Demonstration serves for LM (any Ordinate on the other Side of AR) only changing the Sine + into —; and then it agrees with Mr. *James Gregory*'s *Prop.* 3. *pag.* 17. of his *Exercitations*, viz. *That the Nautical Meridian is a Scale of Logarithms of the Differences whereby the Secants of Latitude exceed their respective Tangents, Radius being Unity.* So here RM is the Logarithm of ML, the Difference of the Secant and Tangent of the Latitude, whose Meridional Part is RM.

19. Supposing the precedent Construction, if through any Point C of the Curve ACB be drawn a right Line GCW parallel to MR, terminated with the Logarithmic Curve in W and the Radius AR in G: I say, that the same right Line WG is equal to the intercepted Part of the Curve Line AC.

20. Let wg be a Line infinitely near and parallel to WG, and terminated by the same Lines; and CS, $W\sigma$, perpendicular to the Meridian; CS intersecting wg in z, and $W\sigma$ in y. Let CM be a Tangent to AC in C; $W\tau$ a Tangent to AW in W; so is $CM = \sigma\tau$. Because of like Triangles Czc, CSM; and Wyw, $W\sigma\tau$; $CS : CM :: Cz : Cc$: also $W\sigma : \sigma\tau :: Wy : yw$. But $W\sigma = CS$; $\sigma\tau = CM$; $Cz = Wy$; therefore is yw the Fluxion of GW, equal to Cc, the Fluxion of the Curve AC. Consequently $GW = AC$ *q. e. d.*

21. It may be noted, that this Equitangential Curve gives the Quadrature of a Figure of Tangents ſtanding perpendicular on their Radius. In *Fig.* 214. let $A\gamma\Gamma$ be a Curve, whoſe Ordinates as $g\gamma$, $G\Gamma$, are equal to the Tangents of their reſpective intercept Arcs Ak, $A\kappa$. Let ΓG be produced to touch the Curve AC in C: then is the Area $A\Gamma G$ equal to the Rectangle contained by Radius AR and GC the produced Part of the Ordinate; or $A\Gamma G = AR \times GC$. The Demonſtration of which, and of the following *Section*, I for Brevity omit.

22. If we ſuppoſe the Figure ACB, &c. KR (*Fig.* 214.) infinitely continued, to be turned about its Aſymptote RK as an Axe, the Solid ſo generated will be equal to a Rectangled Cone, whoſe Altitude is equal to AR; And its Curve Surface will be equal to half the Surface of a Globe whoſe Radius is AR. So that if the Curve be continued *both ways* infinitely (as its Nature requires) the whole Surface will be equal to that of a Globe of the ſame Radius AR.

The Deſcription of the Rular and Wheel, *Fig.* 213. is ſufficient for the Demonſtration of the Properties of the Curve: but in order to an actual Conſtruction for Uſe, I have added *Fig.* 216. where AB is a Braſs Rular; *wh* the little Wheel, which muſt be made to move freely and tight upon its Axe (like a Watch-Wheel) the Axe being exactly perpendicularly to the Edge of the Rular. *s* repreſents a little Screw-pin to ſet at ſeveral Diſtances for different Radii, and its other End is to ſlide by the Edge of the other fix'd Rular. *p* is a Stud for the convenient holding of the Rular in its Motion. Fig. 213. Fig. 216.

N. B. *Moſt of the Properties of this* Curve *by the Name of* la Tractrice, *are to be found in a* Memoire *of M.* Bomie *among thoſe of the* Royal Academy *of* Sciences *for the Year* 1712, *but not publiſhed till* 1715: *Whereas this Paper of Mr.* Perks *was produced before the* Royal Society *in* May 1714, *as appears by their* Journal.

VII. 1. I have lately thought of a New Inſtrument for drawing a Meridian Line; it is eaſy in its Uſe, and ſufficiently exact.

A New *Way of drawing a* Meridian Line, *by Mr.* S. Gray. n. 268. p. 763.

Take the Gnomon of an Horizontal Dial for the Latitude of the Place, and to the *Hypothenuſa* fix Two Sights, whoſe Centers may be parallel to the ſame: let the Eye-ſight be a ſmall Hole; but the other's Diameter muſt be equal to the Tangent of the double Diſtance of the *North-Star* from the Pole, (the Diſtance of the Sights being made *Radius.*) Let the Stile be riveted to the End of a ſtraight Rular: When you would make uſe of it, lay the Rular on an Horizontal Plane, ſo that the End to which the Stile is fix'd may over-hang; then look through the Eye-ſight, moving the Inſtrument, till you ſee the North-Star appear to touch the Circumference of the Hole in the other Sight, on the ſame Hand with the Girdle of *Caſſiopeia*; or on the oppoſite Side to that, whereon the Star in the Great Bear's Rump is, at that Time:

Time: then draw a Line by the Edge of the Ruler; and it will be a true Meridian Line, as it is eaſy to demonſtrate.

I do not hear that any of the Occultations of *Aldebaran* by the Moon were obſerv'd laſt Year: I expected ſeveral, but was always hindred by the Weather from obſerving any.

— *on the* ſame *by the* ſame. n. 270. p. 815.

2.] I have ſent ſome farther Thoughts upon the Inſtrument for drawing a Meridian Line, and have improved it ſo far, than no other *Star* will be made uſe of than the *Polar* one to obtain the Hour and Minute of the Day or Night.

Let there be taken a Teleſcope of about 16 Foot, or longer if you pleaſe; in the Plane of its Focus place a Ring of Braſs at right Angles to the Axis of the Glaſs, the Diameter of the inward Circle equal to the double Tangent of the Pole-Star's Diſtance from the Pole; the focal Length of the Object Glaſs being made Radius, as was ſaid in the Deſcription of the Meridian Inſtrument; let the Ring be divided into 24 Hours, with their Minutes number'd from the Right-hand towards the Left, as in our common Nocturnals; the Eye-Glaſs muſt be equal in its Diameter to the Horary Ring: but this perhaps will be thought too chargeable, eſpecially for ſuch large Teleſcopes as I am ſpeaking of, which has made me think of this Contrivance: The Eye Glaſs muſt lye in a broad Index towards one End, this is to turn on a Center Pin, that lies in the Center of the Glaſs, and conſequently over the Center of the Horary Ring, from which it muſt be equal to the Diſtance of the Focus of the Eye Glaſs; then let the Tube be elevated to the Height of the Pole, and directed to the Pole-Star, till by turning the Index through the Eye Glaſs, you perceive the *Star* to touch the Horary Ring on that Side the Star in the *Great Bear's Rump* lyes, or on the oppoſite to that in the Hip of *Caſſiopeia*; but on the contrary, had not the Glaſs inverted the Object, then bring one of the twelves to be in a perpendicular to the other by a Plum-line; ſo will the Star ſtand at its Horary Diſtance from the Meridian; or if the Latitude of the Place be unknown by the Right Aſcenſion of the Sun and Star, the Time of its coming to the Meridian will be eaſily obtained; and then the Hour of the Night found, will as eaſily give the Star's Horary Diſtance from the Meridian; then elevate the Tube towards the Star, bringing the Meridian, or 12 and 12 into the Plane of the Perpendicular; turn the Glaſs about, till you ſee the Pole Star ſtand at its Horary Diſtance from the Meridian; ſo will the Inſtrument when fixed, ſhew the Horary Diſtance throughout the whole Day, or as long as it remains in this Poſition, by the apparent Motion of the Star in the Ring. The beſt Time to fix the Inſtrument will be, when this, or any of the other two Stars above-mentioned, are about 6 Hours from the Meridian. It is to be obſerv'd, that the Latitude of the Place is now given with the utmoſt Preciſeneſs: for the Axis of the Glaſs lies now in the

the Axis of the World; and if one of the Sides of the Tube be parallel thereto, as it ought to be at the upper End, hang a Line and Plummet from the Point of the Sufpenſion; find another Point equal in Diſtance to the Length of the Line, or a Knot towards the lower End, the Diſtance from this Knot to the former Point will be but the Chord of the Latitude; and if from the ſame Edge of the Index, another Line and Plummet be hung towards the lower End of the Tube, theſe two Lines, when at reſt, will be in the Plane of the Meridian.

This Inſtrument may be made to ſhew the Hour with as much Facility as a Clock or Sun-dial, if the Horary Ring be made to move within a larger fixed one; and the outward Circle of the former be divided into the Days of the Month, reſpect being had to the Right-Aſcenſion of the Sun and Star: Then by bringing the two oppoſite Points in the fixed Circle to the Perpendicular, which is done at the fixing the Inſtrument, move the Circle till the Day of the Month come to any of theſe, and the Ring is rectified for that Day; and if the Air be clear, you will ſee the Star ſtand at the true Time of the Day or Night.

It may be objected, that in a few Years, by the Annual Increaſe of its Declination, the Pole-Star will, by moving in a leſſer Circle, be brought too far from the Edge of the Ring, that the exact Hour and Minute cannot well be diſtinguiſh'd: but this Inconveniency, when it is one, may be eaſily remedied ſeveral Ways; either by making a leſſer Ring, or by extending a fine Thread of Silk croſs the Ring, till it cuts the Star, and at the ſame Time it gives the Hour; or, which will yet make this Inſtrument commodious for other Purpoſes, there may be made an Index to move on the Center of the Hour-wheel, which being brought to cut the Star with the Edge that proceeds from the Center, it will at the ſame Time cut the Hour: And now we need not be ſollicitous about the exact Diameter of the Ring, provided it do but a little exceed the Diſtance of the Pole-Star from the Pole, the focal Length of the Glaſs being made Radius.

Mr. *Flamſteed* has diſcovered, that there is a Parallaxis of the Earth's Annual Orbit at the Pole-Star of about 40 or 45 Seconds; whereby the Diameter of the Star's Parallel is greater in *June* than in *December*, by about 1 Min. 2 Seconds; which he has evinced from ſeven Years ſucceſſive Obſervations, whereby the Earth's Motion is indubitably demonſtrated, as appears from his Letter to Dr. *Wallis* on that Subject.

Now if on the Edge of this Index there be drawn a Scale of Degrees, Minutes and Seconds, to the Radius of the Glaſs, we ſhall not only have a very accurate Inſtrument for the Hour, but be furniſhed with one, whereby we ſhall ſee the Truth of the Earth's Motion confirmed by the Acceſs and Receſs of our Star towards and from the Pole, according to the Earth's Place in the Ecliptick, as that learned Perſon has diſcovered; and that not only when the Star tranſits the Meri-

Meridian, but in clear Air at any Time of the Day; one ſhall likewiſe obſerve that Annual Increaſe of the Pole-Star's Declination, cauſed by the Preceſſion of the Equinox.

My own Obſervations aſſure me, that the Pole-Star may be ſeen in the Day time with a Teleſcope of 16 Foot; for with one of this length I ſaw that Star on the 26*th* of *April* 1701, from 4 o' Clock in the Morning till 7, and could have ſeen it longer, had not Clouds interpoſed; and again the firſt of *May*, I did not look for the Star, till the Sun had been up more than half an Hour, *viz.* at 5 in the Morning, yet I ſoon found it, and ſaw it afterwards as oft as I pleaſed, till half an Hour after 9 the ſame Morning; ſo that I doubt not, this Star may be ſeen in a clear Day throughout the whole Year.

The Declination of the Pole-Star for the Year 1700, is 87° 42′ 51″, as I find it by *Ricciolus*'s Catalogue of fixed Stars, in the Appendix to Sir *Edward Sherbourn*'s Sphere of *Manilius*, *&c.* Hence its Diſtance from the Pole at this Time may be aſſumed 2° 17′. the focal Length of my Object Glaſs is 15 Foot 6 Inches, ſo that the Diameter of the Ring will be 14 Inches, and 84 hundredth Parts of an Inch, which is the natural Tangent of the former Arch 2° 17′ doubled; a Circle large enough to be divided into Minutes and Halves, which will be ſo magnified by the Eye-Glaſs, that it will be eaſy to diſtinguiſh the Time to a few Seconds.

It is true, there is ſome Difficulty in fixing up this Inſtrument; and when it is ſo, to keep it from varying from its due Poſition; but yet it is not inſuperable: But for ſmall Inſtruments, of about 2 or 3 Foot long, there cannot be a more accurate, eaſy, and expeditious Way than this for drawing a Meridian Line. But whether the many Benefits that may accrue to Aſtronomy, do not make the larger one worth the Charge and Trouble of compleating it, I leave to the Conſideration of the Learned.

An Inſtrument *for finding the* Meridian. *By Mr.* W. Derham. n. 291. p. 1578.

VIII. Among all the Ways contriv'd for finding the Meridian of any Place, the moſt commodious, I think, is an Inſtrument of Sir *Chr. Wren*'s, or two of Mr. *Gray*'s, or one publiſh'd in the Appendix of a Book call'd the *Artificial Clockmaker*.

Sir *C. Wren*'s Contrivance, I am informed, is thus: At one End of a Ruler, erect a Sight, to ſee the Pole-Star, *&c.* through. At the other End ſet up two Circles of ſmall Wire, one within the other; the Diameter of the innermoſt, equal to the doubled Tangent of the Diſtance of the Pole-ſtar from the Pole, the Diſtance of the Sight being Radius; and the Diameter of the outermoſt Circle, equal to the double Tangent of the Diſtance of the next Star to the Pole-Star, from the Pole. Your Inſtrument thus prepared, if you look thro' the Sight, and bring the two Circles to the two Stars, whoſe Diſtances from the Pole they repreſent; a Line paſſing through a Sight and Center of the Circles, is the Elevation of the Pole: and two Plumb-lines hung up, one over the

Fig. 211.

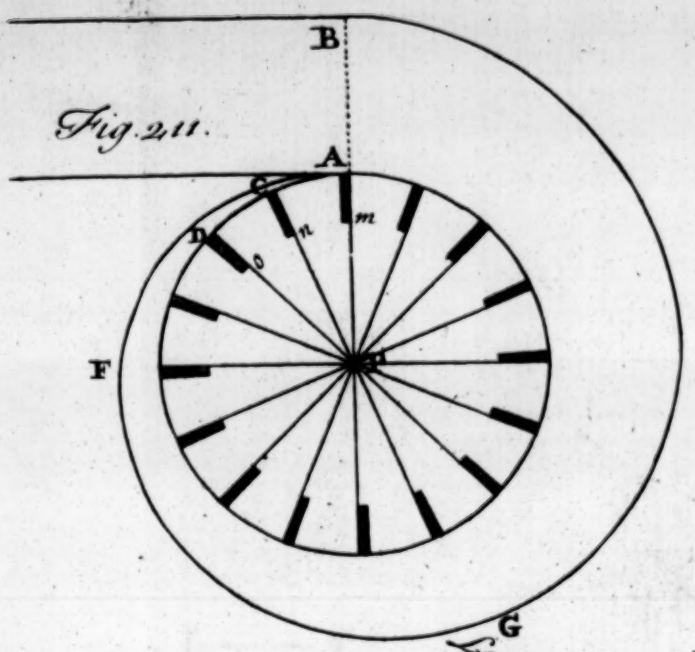


Fig. 210.

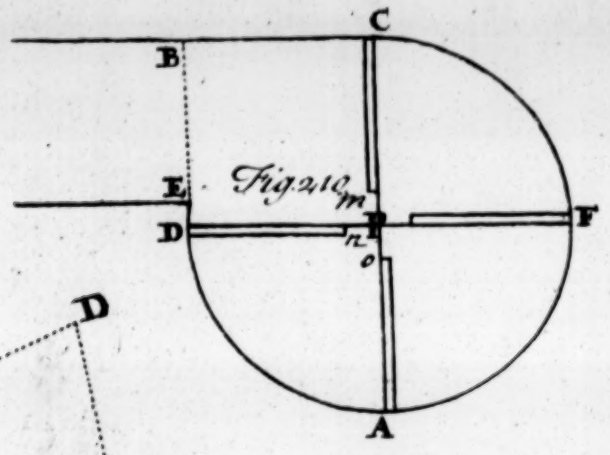


Fig. 212.

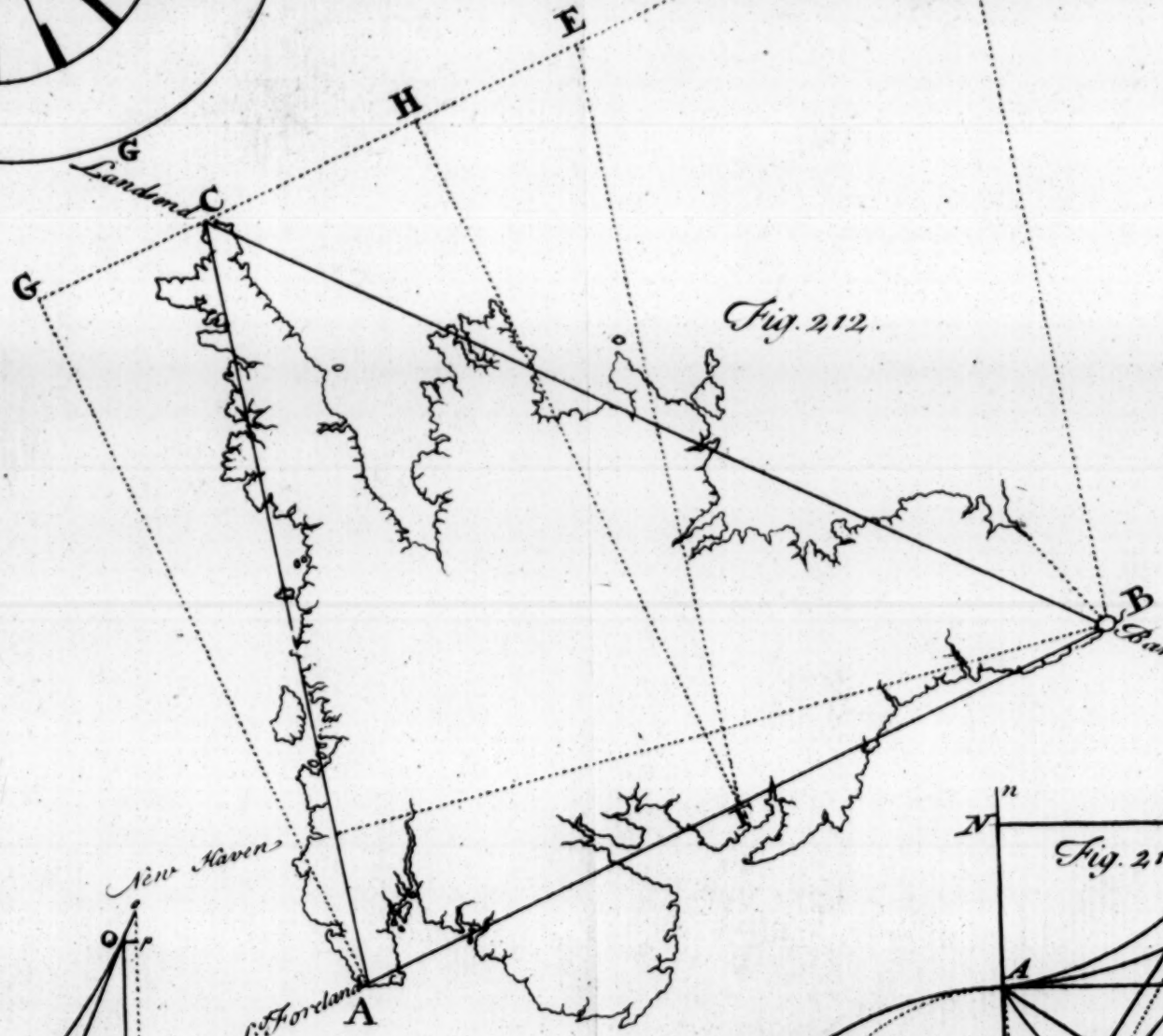


Fig. 213.

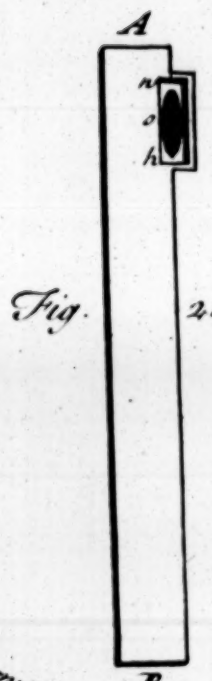


Fig. 216.

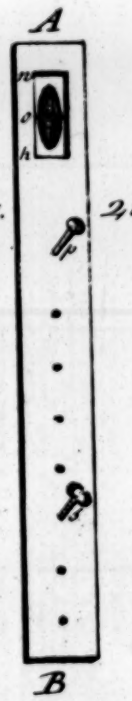


Fig. 214.

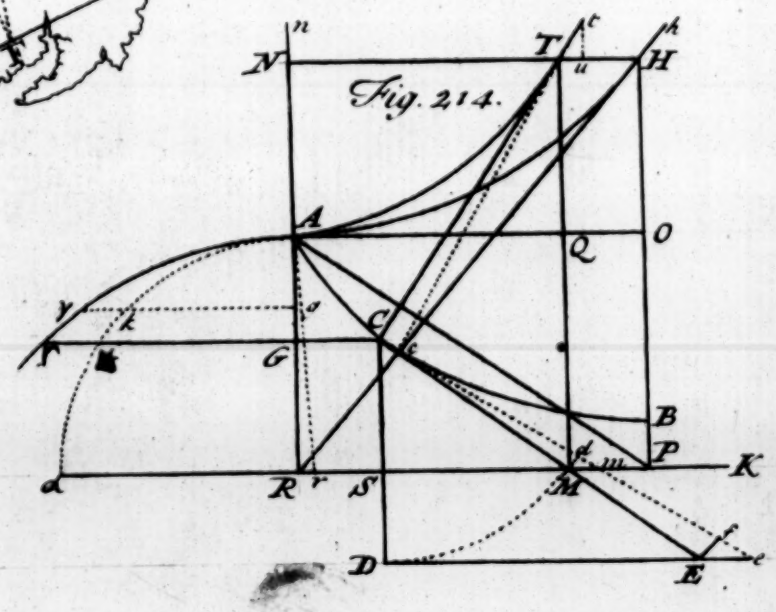
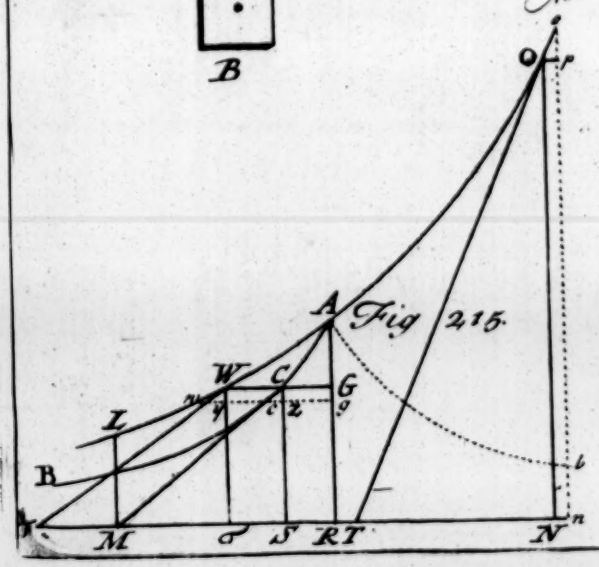
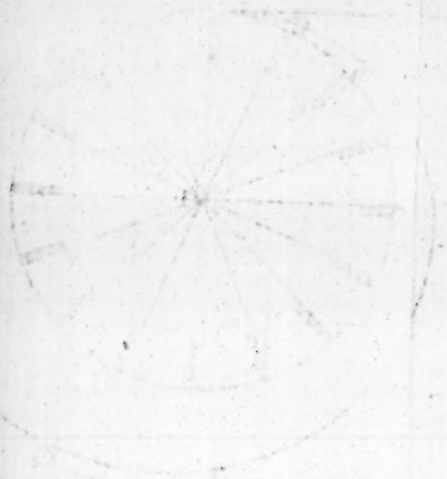


Fig. 215.





the Sight, the other over the Centre of the two Circles, will exactly lye in the Meridian of the Place.

Mr. *Gray*'s Contrivances being Printed, I need not give any Deſcription of them.

The laſt Inſtrument is what I have made uſe of for ſeveral Years, and I would recommend it, upon my own Experience, for a very nice Way to find the Meridian of any Place, and to ſee the *Tranſits* of the Celeſtial Bodies over it, either Northward or Southward.

The Inſtrument is thus made of Wood, or rather Iron, or Braſs, to endure the Weather, without ſwelling or contracting, *viz.* Prepare a ſmall flat Iron Bar, *C*, *C*, at each End of which rivet on two upright Sights, to turn ſtiffly, at the Joints *I*, *I*. Let one of the Sights *c*, *d*, have a Perforation big enough to ſee the *Pole-Star* through it; the other Sight *a*, *b*, a very ſmall Perforation, to ſee the *Sun* through. Juſt behind the Joints fix two upright Arms *C*, *D*, and *C D*, but to bend off, ſo as to be out of the Way of the Sights, when you look through them. Theſe Arms ought to be long enough for the Plumb-lines to reach the Polar-Star, on the one Side; and the Sun at his greateſt Height, on the other Side, when you look through either of the Sights. The Plumb-lines therefore are Tangents to their oppoſite Sights, and their Lengths may be found by a Table of natural Tangents, and making the Diſtance of the two Sights Radius. Thus in the Latitude of *London*, if the Inſtrument be two Feet from Sight to Sight, the Southern Plumb-line hath need to be near 4 Feet, and the Northern Plumb-line about 2 Feet 10 Inches. On the Tops of theſe two Arms, place two ſmall croſs Pieces *D E* and *D E*, to turn with a Point at *D*, which Croſs-Pieces are to hold the Plumb-lines *E F* and *E F* and to turn off and on, ſo as to bring the Plumb-lines to the Sights exactly. Place this Inſtrument on a Pedeſtal *H* to turn round on it ſtiffly at the Pin *G*.

Your Inſtrument being thus prepared, the Way to *Set and Uſe it* is thus; plant it in a convenient Place, where the Polar-Star may be ſeen by Night, and the Sun by Day. When that Star is on the Meridian, is the Time to ſet this Inſtrument, which is thus to be done, *viz.* Through the Sight with the large Hole *c*, *d*, look at the Pole-Star, and turn the whole Inſtrument about, until you ſee the oppoſite Plumb-line nicely to interſect the Pole-Star. Or when you have brought the Plumb-line near the Star, you may more eaſily bring the Plumb-line to interſect, by moving the Sight *c*, *d*, backward or forward, at the Joint I, inſtead of the moving the whole Inſtrument. And that you may more eaſily ſee the Pole-Star through the Sight, let the Plumb-line be a very fine Cats-gut ſtring or Horſe-hair, *&c.* And if it be white, or ſome ſuch light Colour, it will be the better ſeen, with the Help of a Candle ſhining on it by Night, which is neceſſary.

The Sight *c*, *d*, and oppoſite Plumb-line being thus ſet in a direct Line with the Polar-Star on the Meridian, it is manifeſt, that the In-

ſtrument lieth exactly in the Meridian, ſo as to ſee any Star on the Meridian to the North. And that you may ſee the ſame Southerly; the next Day, or when you pleaſe, you may hang up the Plumb-line E, F, upon the Southern Arm *C*, *D*, ſo as that the Plumb-line may exactly interſect the Perforation *c*, *d*. This may eaſily be done by moving the top Joint, with the Plumb-line on its Croſs-piece backward and forward, till the Plumb-line hangeth to your Mind. If the Sight with the leſſer Perforation *a*, *b*, be not exactly under the Northern Plumb-line, it muſt be brought to be ſo, by turning the Sight, by Help of its Joint at I; and then all the Inſtrument is ſet right, ſo as to ſee the Sun, Moon or Stars, come on the Meridian towards the South.

But to ſee the Sun tranſit the Meridian, it is neceſſary to guard the Eye, with a colour'd Glaſs, or a Glaſs darkened with the Smoak of a Lamp or Candle.

A Glaſs *to look through upon the* Sun.

Chuſe two Pieces of Glaſs cut into the ſame Size and Figure; but take Care they do not refract vitiouſly; which may be known by moving the Glaſs before the Eye. If the Objects you look on ſeem to dance about, the Glaſſes are falſe and refract; but true if all ſeems ſteady. Smoak one of theſe Glaſſes over the Flame of a Lamp or Candle, until it be obſcured enough to take off the Sun-rays ſufficiently, but not ſo as to darken it too much. This may be ſeen by looking upon the Sun with it, or upon the Candle. One of the Glaſſes being thus darkened, lodge them both together, and faſten them in a little Caſe fit for the Purpoſe, with the ſmoaked Side innermoſt, and an edging of Card between, to keep the Glaſſes aſunder, ſo as that the Soot may not be rubb'd off, or diſordered.

'Tis good to have two Glaſſes thus prepared, one for a ſtrong Sun; the other leſs darkened, for the Sun behind a thin Cloud, Miſt, or, *&c.*

With one of theſe Glaſſes held behind, or before the Sight *a*, *b*, you may plainly ſee the Sun paſs.

— *the ſame Inſtrument varied.*

Inſtead of an intire Inſtrument, prepare only two Sights (as in *Fig.* 218.) with Perforations as before. Let theſe Sights be nailed or ſcrewed down, upon the Tops of two Stakes at *I*, *I*, ſo as to turn ſtifly upon them. The Plumb-lines (one at leaſt) may be hung up at the End of an Houſe (as at *K*, *Fig.* 218.) or on the Bough of a Tree (if the Wind would not ſhake it) or any where you ſee fit: And the Sights muſt be ſtuck up, ſo as to bring the Pole-Star to interſect, and all be performed, as hath been before directed.

Fig. 218.

This, although in a Manner the ſame with the Inſtrument before, yet is more convenient in ſome Reſpects. Chiefly becauſe the Plumb-lines may be made longer, and the Sights ſet farther aſunder, than in the Inſtrument before can conveniently be done; which is ſome, altho' no great Advantage for ſeeing the Tranſits. Alſo, theſe Sights may be made ſo light, as to be eaſily carried about; or they may be eaſily made, or imitated in any Place where-ever you come.

To

To know when the *Polar-Star* comes on the *Meridian*, the Way is this; ſubtract the *Right Aſcenſion* of the *Sun* from the *Right Aſcenſion* of the *Pole-Star*, the *Remainder* giveth the Degrees, Minutes and Seconds when the Pole-Star tranſits the Meridian above the Pole. Divide theſe Degrees by 15, it gives the Hours; and every Degree under 15 multiplied by 4, gives the Minutes; and every Minute multiplied by 4, gives the Seconds, of apparent Time of the Pole-Star's Southing. I ſcarce need ſay, that it comes under the Pole at 12 Hours Diſtance, only making ſome ſmall Allowance for the Alteration of the Sun's *Right Aſcenſion* in that 12 Hours Time. *To know when the* Polar-Star *comes on the* Meridian.

But you may ſhorten your Labour, by uſing Tables of the Sun's R. Aſc. in *Time*, inſtead of his R. Aſc. in *Degrees*, &c.

If the Sun's R. Aſc. exceedeth the Pole-Star's, add 360 Degrees, or 24 Hours, and then ſubtract.

The R. Aſc. of the Pole-Star is determin'd by Mr. *Flamſteed* to be $0^h. 33'. 4''.$ of *Time*, Anno 1690, and the Increaſe of its R. Aſc. in 10 Years $1'. 16''.$ of *Time*. Therefore this preſent Year 1703, the R. Aſc. of the Pole-Star is $0^h. 35'. 22''.$ of *Time*.

Or you may ſee, when the Pole-Star cometh to the Meridian, by hanging up a Plumb line, and obſerving when the *Thill Horſe* in *Charles's Wain* called *Alioth*, comes near the Line, together with the Pole-Star, on one ſide the Pole; or the bright Star of the Third Magnitude in *Caſſiopeia's Thigh* on the other ſide, as is repreſented in *Fig.* 219. Fig. 219.

The foregoing Inſtruments may be ſet by any other Star, as well as the Pole-Star. But the Pole-Star in our Northern Hemiſphere, is moſt convenient, becauſe it maketh but a ſmall Circle round the Pole, and therefore moves ſlower, and conſequently is longer in tranſiting the Meridian. And therefore a ſmall Error in Calculation, or a little Expence of Time in ſetting the Inſtrument, may be admitted.

The Uſes of theſe Inſtruments are, 1. You may ſee with all imaginable Exactneſs, when it is *Noon*, even to 1, 2, or at moſt 3 Seconds of Time. For you may ſee, when the very Limb of the Sun toucheth the Meridian, and whilſt all his Diſk is paſſing it. So that by much it exceeds all Sun Dials: ſo far that if you once uſe this Inſtrument, you will be ready to lay aſide all Sun-Dials; the beſt of which (unleſs we except Mr. *Molineux*'s) can never ſhew the Time to one or many Seconds. *The* Uſes *of theſe Inſtruments.*

But beſides all this, another vaſt Conveniency is, That it will *fit moſt Latitudes*. So that there is no Need of having a ſtrict Regard to the Elevation of the Pole, nor any Danger of Error in making and ſetting, as is in moſt other Inſtruments, but all is with Eaſe and Certainty performed. Therefore,

2*dly*, Into whatſoever Place you come, you may eaſily ſee the Errors of the Sun-Dials there, and which go trueſt, and which falſe.

3*dly*, As the Sun, ſo alſo the fix'd Stars may be ſeen to tranſit the Meridian, whereby the *Hour of the Night* may as exactly be known, as

of the Day by the Sun, knowing the R. Aſc. of the Star that tranſits. For (as before for the Pole-Star) ſubtract the R. Aſc. of the Sun from the R. Aſc. of the Star, the Remainder converted into Time, is the Time of that Star's Culmination or Southing. And if 12 Hours be added or ſubtracted (making due Allowance for the Alteration of the Sun's R. Aſc. in that Time) it ſheweth the exact Time of that Star's coming to the Meridian Northward.

4thly, The Hour of the Day and Night being thus to 1, 2 or 3 Seconds, diſcoverable by the aforeſaid Inſtruments, I doubt not, but that they may be uſeful in finding the exact *Differences of Meridians*, either by the *Eclipſes of Jupiter*'s *Satellites*, or the *Occultation* of the *Fix'd Stars* by the *Moon*.

I do not pretend, that theſe Inſtruments are any otherwiſe uſeful in finding the *Longitude*, than by ſhewing the exact Time of the Day or Night; which is one Thing abſolutely neceſſary in this Matter. Neither indeed will they ſerve without a well adjuſted Pendulum-Watch or Pocket-Watch, that will keep Time exactly from one Obſervation by the Meridian-Inſtrument to another. Nor indeed are they uſeful on Shipboard, but only on Land, where they can remain fix'd. But on Head-Land, or any where on Shore, they may be uſeful to the Seaman: And indeed (until better Diſcoveries are made) theſe Meridian-Inſtruments may be of Uſe, where-ever long Teleſcopes can be of Uſe, for ſeeing the *Appulſes* of the *Moon* to the *Fix'd Stars*, or the Eclipſes of *Jupiter*'s *Satellites*; which is only on Land: Unleſs (which I have thought feaſible) a convenient ſtanding for a Man, a Teleſcope might be hung pendulouſly in a Ship, which (eſpecially in a calm Sea) may be as little ſubject to Diſturbance, as the Pendulums of Watches are, which will retain their Motion at Sea.

5thly, You may with all Exactneſs continue a Meridian-Line for many Miles, by looking through either Sight, and ſeeing what Objects are interſected by the Plumb-Lines.

Of a Meridian Line *drawn thro'* France, *&c. Communicated by Mr.* Geoffroy, n. 278. p. 1097.

IX. Monſieur *Caſſini* open'd the *Aſſembly* (of the *Academy Royal of Sciences*, Nov. 12. 1701.) with a Diſcourſe containing the Obſervations he had made in his laſt Voyage, with a Deſign to determine the Paſſage of a *Meridian-Line* (taken from a Point in the *Obſervatory* at *Paris*) from one End of *France* to the other. In the firſt Part of this Diſcourſe, he went back to the moſt ancient Aſtronomers, and recounted their Opinions of the Spheric Figure of the Earth, and their Methods to know its Dimenſion; and then proceeded to thoſe of the Moderns. And in the laſt Place, he related the Method of the late Monſieur *Picard*, of the *Academy Royal*, as the moſt exact. Then he ſpoke of his own Obſervations on the ſame Subject, of the Uſe he had made of the *Satellites* of *Jupiter*, more fit for this than the Eclipſes of the Moon, in that they are more frequent; and ſaid that his Obſervations had been confirmed by the like made in *China*. He ſhewed the Method he took to determine

mine the Paſſage of the *Meridian* taken from a Point in the Obſervatory at *Paris*. By the Means of Triangles, which he made through the whole Courſe of his Journey, and very exact Calculations, he determined the Place of this Meridian, and marked all the conſiderable Places through which it paſſed, from *Paris* to the higheſt Mountains of the *Pyreneans*, which ſeparate *Rouſſillon* from *Catalonia*; among theſe Mountains he obſerved one of a prodigious Height, it being 1440 Toiſes high. But the moſt extraordinary Obſervation was that of the Inequality of the Degrees of the Meridian on the Earth; which is ſuch, that Monſieur *Caſſini* found that going Southward one Degree ſurpaſſed another an 800*th* Part, which may give great Reaſon to doubt of the exact Roundneſs of the Earth. Upon this Occaſion he reported two different Opinions: The one of Monſieur *Huygens* and *Newton*, the other of a Mathematician of *Straſburg* named *Eiſenſchmidius*. The two former hold, that the Earth is flatted towards the Poles, ſo that it is ſomething of the Shape of an *Holland* Cheeſe: Which they both conclude by Phyſical and Algebraical Deductions, from an Obſervation made at *Cape Verd*; that the Pendulums, though of the ſame Length, make their Vibrations there much ſlower than in the Northern Countries. The other Mathematician holds, that the Figure of the Earth is Elliptique, ſo that it is ſtretch'd out towards the Poles, and has the Form of an Egg. M. *Caſſini* left the Queſtion undecided. The Cities through which he obſerv'd the *Meridian* of *Paris* to paſs, are *Dunkirk*, *Amiens*, *Aubigny*, *Bourges*, *Aurillac*, *Rodez*, *Alby*, and *Carcaſſone*.

X. *A Paper Omitted.*

Guilielmi Muſgrave Regiæ Societatis Socii de *Britanniâ* quondam *Pene-Inſulâ*, Diſſertatio. n. 352. p. 589.

Chap. VII.

MUSIC.

I. HAving made the Trial of a Muſical Experiment before the *Society*, I ſhall give a farther Account of it; that the *Theory* of *Muſic*, which is but little known in this Age, and the *Practice* of it which is arriv'd to a very great Excellency, may be fixed upon the ſure Foundations of *Mathematical* Certainty.

The Theory of Muſic *reduced to* Arithmetical *and* Geometrical Proportions *by Mr.* T. Salmon, n. 302. p. 2073.

The Propoſitions, upon which the Experiment was admitted, were; That Muſic conſiſted in *Proportions*, and the more exact the Proportions, the better the Muſic: That the Proportions offer'd were the ſame

that the Ancient *Grecians*. us'd: That the Series of Notes and half Notes was the ſame our Modern Muſic aimed at: Which was there exhibited upon Finger-boards calculated in Mathematical Proportion. This was demonſtrated upon a Viol, becauſe the Strings were of the greateſt Length, and the Proportions more eaſily diſcern'd; but may be accommodated to any Inſtrument, by ſuch mechanical Contrivances as ſhall render thoſe Sounds, which the Muſic requires.

To prove the foregoing Propoſitions, two Viols were Mathematically ſet out, with a particular Fret for each String, that every Stop might be in a perfect Exactneſs: Upon theſe, a Sonata was perform'd by Mr. *Frederick* and Mr. *Chriſtian Stefkins*; whereby it appear'd, that the Theory was certain, ſince all the Stops were owned by them, to be perfect. And that they might be prov'd agreeable to what the beſt Ear, and the beſt Hand performs in modern Practice; the famous *Italian*, Signor *Gaſperini*, plaid another Sonata upon the Violin in Conſort with them, wherein the moſt compleat Harmony was heard.

The full Knowledge and Proof of this Experiment may be found in the two following Tables, wherein Muſic is ſet forth, firſt Arithmetically and then Geometrically: The Mathematician may, by caſting up the Proportions, be ſatisfied that the five ſorts of half Notes here ſet down, do exactly conſtitute all thoſe Intervals, of which our Muſic does conſiſt. And afterwards he may ſee them ſet forth upon a Monochord, where the Meaſure of all the Notes and half Notes comes exactly to the middle of the String. The Learned will find, that theſe are the very Proportions which the old *Greek* Authors have left us in their Writings, and the practical Muſician will teſtifie, that theſe are the beſt Notes he ever heard.

The Explication of the Firſt Table.

Between the two loweſt Lines, you have the Series of all the 12 half Notes in an Octave, from A *re* to A *lamire*, which added together make an Octave or exact Duple Proportion: The ſeveral Parts alſo added together make all thoſe Intervals of which it is conſtituted. As for Example, the two half Notes from A to A ♯ $\frac{17}{18}$, and from A ♯ to B $\frac{16}{17}$ make a Major Tone $\frac{8}{9}$; to which if an Hemitone from B to C $\frac{15}{16}$ be added, you have a leſſer Third $\frac{5}{6}$.

In like Manner between the two next Lines, you have the Series of all the 12 half Notes, in an Octave from C *fa ut* to C *ſol fa ut*: The two firſt Tones added together make a greater Third: And ſo you may add a Tone or Hemitone, till you arrive at every Interval in the Octave, which is ſo call'd, becauſe eight Sounds are required for expreſſing thoſe ſeven gradual Steps, whereby we commonly aſcend to it.

It may be alſo obſerv'd, that the Proportions falling upon the ſame Notes in two Keys, one Finger-board will be ſufficient for both.

It is acknowledg'd by all that are acquainted either with Speculative or Practical Muſic, that every Interval is divided into two Parts, whereof one is greater than the other: An Eighth $\frac{1}{2}$ into a Fifth $\frac{2}{3}$ and a Fourth

Fourth $\frac{3}{4}$. Again, a Fifth $\frac{2}{3}$ into a greater Third $\frac{4}{5}$, and a leſſer Third $\frac{5}{6}$. Thus alſo a greater Third $\frac{4}{5}$ muſt be divided into a Tone Major $\frac{8}{9}$ and a Tone Minor $\frac{9}{10}$. The Leſſer Third (to comply with the Practice of Muſic) is rather compounded of, than divided into a Tone Major $\frac{8}{9}$ and an Hemitone, which is its Complement, $\frac{15}{16}$.

TABLE I.

TABLE the 1*ſt*.

Containing the Proportions ſet out *Arithmetically*.

						An Eighth	$\frac{1}{2}$
					A Seventh	$\frac{8}{15}$	
				A Sixth	$\frac{3}{5}$		
			A Fifth	$\frac{2}{3}$			
		A Fourth	$\frac{3}{4}$				
	A Greater Third	$\frac{4}{5}$					
	$\frac{8}{9}$	$\frac{9}{10}$	$\frac{15}{16}$	$\frac{8}{9}$	$\frac{9}{10}$	$\frac{8}{9}$	$\frac{15}{16}$
	Tone Major :	Tone Minor	Hemitone	Tone Major	Tone Minor	Tone Major	Hemitone

An Octave with a greater Third. C $\frac{17}{18}$ ♯C $\frac{16}{17}$ D $\frac{19}{20}$ ♯D $\frac{18}{19}$ E $\frac{15}{16}$ F $\frac{17}{18}$ ♯F $\frac{16}{17}$ g $\frac{19}{20}$ ♯g $\frac{18}{19}$ a $\frac{17}{18}$ ♯a $\frac{16}{17}$ b $\frac{15}{16}$ c.

A $\frac{17}{18}$ ♯A $\frac{16}{17}$ B $\frac{15}{16}$ C $\frac{17}{18}$ ♯C $\frac{16}{17}$ D $\frac{19}{20}$ ♯D $\frac{18}{19}$ E $\frac{15}{16}$ F $\frac{17}{18}$ ♯F $\frac{16}{17}$ g $\frac{19}{20}$ ♯g $\frac{18}{19}$ a — An Octave with a leſſer Third $\frac{5}{6}$.

Three Tones Major, two Tones Minor, and two of the aforeſaid Hemitones, placed in the order found in the Scheme, exactly conſtitute the practical Octave; which is ſo call'd, becauſe it conſiſts of eight Sounds, that contain the ſeven gradual Intervals. But it is alſo neceſſary to ſet down the Diviſions of the whole Tones, which are the true Chromatic half Notes, becauſe there is great Uſe of them in Practical Muſic.

To make all our whole Notes, and all our half Notes of an equal Size, by falſifying the Proportions, and bearing with their Imperfections, as the common Practice is, may be allow'd by ſuch Ears, as are vitiated by long Cuſtom: But it certainly deprives us of that ſatisfactory Pleaſure, which ariſes from the Exactneſs of ſonorous Numbers; which we ſhould enjoy, if all the Notes were truly given according to the Proportions here aſſign'd.

It is very eaſie to ſatisfie our ſelves in the Arithmetical Scheme, by thoſe Operations, which *Gaſſendus* has ſet down in his *Manuduction* to the *Theory* of *Muſic*, Tom. V. pag. 635. As for Example, his Rule for Addition is, That two Proportions being given, if the greater Number of one be multiplied by the greater Number of the other, and the leſſer by the leſſer, the two Numbers produc'd exhibit the compounded Proportions. Thus take a Practical Fifth $\frac{2}{3}$ and a Practical Fourth $\frac{3}{4}$ for the two Proportions given, multiply 3 by 4 and you have 12: then multiply 2 by 3 and you have 6: which compounded Proportion of 12 to 6 makes the Practical Octave $\frac{1}{2}$.

Thus, according to his Arithmetical Operations of Addition, Subtraction, Multiplication, of Continuation and Diviſion, is our whole Syſtem proved, which for the more eaſy Application to Practical Muſic, ſhall be alſo ſet forth Geometrically upon the ſix Strings of a Viol.

The Explication of the Second Table.

Theſe ſix Lines repreſent the ſix Strings of the Viol in the common Tuning.

The ſounding Part of each String from the Nut to the Bridge is ſuppos'd to be 30 Inches long; the two middle Strings C and E are drawn out to 15 Inches, the half of the whole.

'Tis eaſie to meaſure every Interval with a Pair of Compaſſes. Suppoſe you are to take the 20*th* Part of the String G; 'tis an Inch and a half for the firſt half Note; if you take the whole Note from G to A, 'tis the tenth Part, and muſt be three Inches.

After theſe are taken away, your String will be but 27 Inches long, ſo that if you advance one Note, or a Major Tone further, you muſt take a 9*th* Part of it, which will be three Inches more, whereby you arrive at a greater Third, being the fifth Part of the whole String. Thus the Series of all the Notes may be demonſtrated.

All the Strings are Uniſon at the Stops where the tuning requires: So that though the Proportions be carried on as far as the frets allow, yet the String is open the ſame with the Stop of that String to which it is tuned;

tuned; and accordingly the Series of the Notes proceeds as if they were all upon a Monochord.

This Calculation ſerves but for two Keys *A* and *C*, which are called Natural, becauſe they have no eſſential Flats or Sharps.

But becauſe the Compoſer begins upon any Key, and the Series of Notes muſt take its *terminus à quo* from thence; the Inſtrument-maker can provide ſuch moveable Finger-boards as will ſerve exactly for every Key. They are taken out and put in upon the Neck of the Viol, with as much Eaſe as you pull out and thruſt in the Drawer of a Table. Three, or at moſt five of them, will be ſufficient to accommodate all the Keys that are made uſe of.

This Mathematical fixing of the Frets enables every Practitioner, who ſtops cloſe to them, to give the Proportions of the Notes in a greater Exactneſs, than can be done upon the Baſs-Violin, or Violin itſelf: Since they may be ſet forth more perfectly by a Pair of Compaſſes dividing a Line, than the niceſt Ear can direct.

Though the Frets for the ſeveral Strings do not ſtand in a ſtrait Line, and the Places are alſo ſhifted in different Keys, yet the Ear naturally directs the Fingers to them; inſomuch that thoſe Perſons, who have all their Lives Time been accuſtom'd to ſtop upon Frets, that go quite croſs the Finger-boards of their Inſtruments, do with very little Practice fall right upon theſe. Such is the Power of a muſical Genius, as may be undeniably proved by thoſe that play upon the Violin; who, when they change the Key, fall upon the right Stops, though they have no viſible Direction where to ſtop, nor Time to alter, by the Ear, the Note they firſt pitched upon.

By this Standard of Regular Proportions may the Voice be formed to ſing the pureſt Notes; they are all the ſame in Vocal and Inſtrumental Muſic; if then the Inſtrument which governs the Voice be perfect, the Ear will of Neceſſity bring it to Perfection. It is pity that a good natural Voice ſhould be taught to ſing out of Tune, as it muſt do, if it be guided by an imperfect Inſtrument; and this may be the Reaſon why ſo few attain to that Melody, which is ſo much valued; but ſince we now know wherein Perfection lies, a conſtant Practice will come to the Attainment of it. The dividing Wholes into Chromatic Hemitones is very neceſſary, but very difficult for the Voice to be broken to: If it learns from an Inſtrument whoſe whole Notes, and whoſe half Notes are ſuppoſed to be equal, the Sound muſt needs be very uncertain and unharmonical; whereas the Proportions truly fixed, would bring it to a Perfection in the niceſt and moſt charming Part of Muſic.

The Chromatic Hemitones are the ſmalleſt Intervals our modern Muſic aims at, though the Ancients had their Enharmonic quarter Notes, which they eſteem'd their greateſt Excellency: Theſe may alſo in Time be recover'd, ſince we know their Proportions; for as the Diatonic Tone is divided into Chromatic Hemitones, ſo after the ſame manner may the Chromatic Hemitones be divided into thoſe leaſt Enharmonic Intervals, which were ever made Uſe of. But if we go no further,

yet this Experiment demonſtrates the true Theory of Muſic, and brings the Practice of it to the greateſt Perfection.

Of the Ancient Greek *and* Roman Lyre; *and a* Paſſage *in* Horace *explain'd by Dr.* T. Molyneux, n. 282. p. 1267.

II. Reading over lately the *Third* Ode of the *Fourth* Book of *Horace*, which *Scaliger*, *Dacier*, and the reſt of the Critics and Commentators ſo much admire, I hit upon a Paſſage, which I think none of them (and I have examin'd the Chief) have clearly explain'd. The *Ode* begins

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O Mutis quoque Piſcibus
Donatura Cygni, ſi libeat, ſonum!

At firſt it ſeem'd to me a wild Rant, or extravagant Whim for *Horace*, ſo great a Judge and Maſter in the Art of Poetry, ſo particularly remark'd for his Propriety of Thought, in ſo labour'd and exquiſite a Poem, to ſay that his Muſe could give even to *Mute Fiſhes* the melodious Voice of the Swan; I look'd upon the Fancy as perfectly forc'd and groundleſs, founded upon nothing that was real or true in Nature: But upon a ſecond Conſideration, I fancied this might be the Meaning of the Paſſage;

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This put me upon ſearching for Matter of Fact, whether or no the ancient Lyre was made of the Shell of a Tortoiſe; and looking into ancient Authors, I find that it was a current Piece of Hiſtory generally received among the Ancients, that *Mercury* was the firſt Inventor of the *Lyre* (whence *Horace* in his 10*th* Ode of the 1*ſt* Book ſtyles him *Curvæ Lyræ Parentem*) and that he made it of the Shell of a dead *Tortoiſe*, which he accidentally found on the Banks of the River *Nile*. Out of many, I will produce two Teſtimonies to this Purpoſe;

Nicander, who wrote above a 100 Years before *Horace*, in his *Alexipharmaca*, ſpeaking of Antidotes proper againſt the Poiſon of the *Salamander*, recommends both the *Sea* and the *Mountain Tortoiſe* in theſe Words,

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Πυίοις, ἢ ταχινῆσι διαπλώει πλερύγεσσιν,
Ἄλλοτε δ' ὀυρείης κυτισηνόμυ, ἥν τ' ἀκάκηλα
Ἀυδήεσσαν ἔθηκεν ἀνάυδητον πέρ ἐοῦσαν
Ερμείης, ζαρκὺς γὰρ ὑπονόσφισε χελεῖον
Αἰολον, ἀγκῶνας ἧ δύω παρετείναλο πέζαις.

Thus

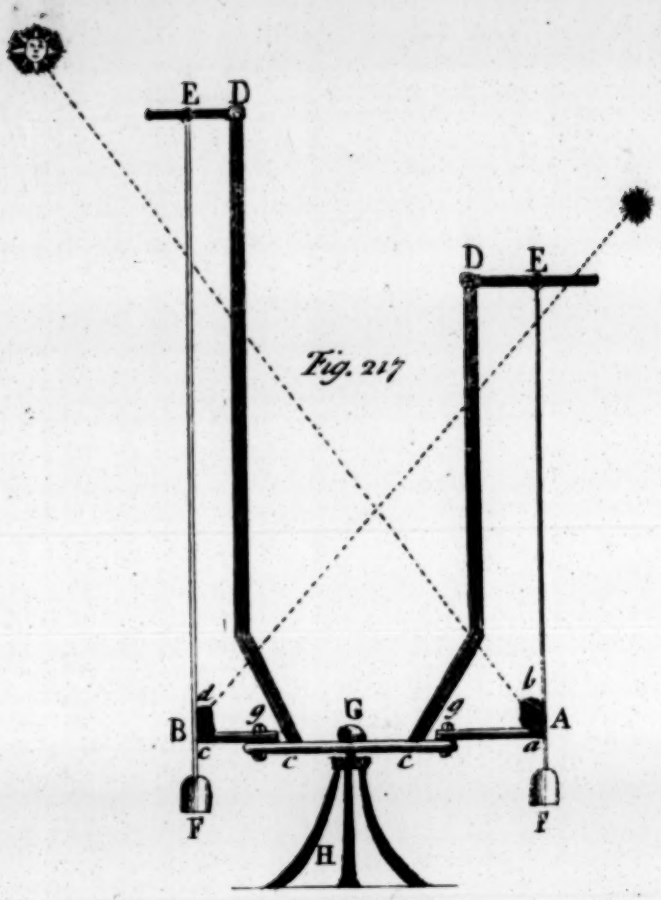

Fig. 217

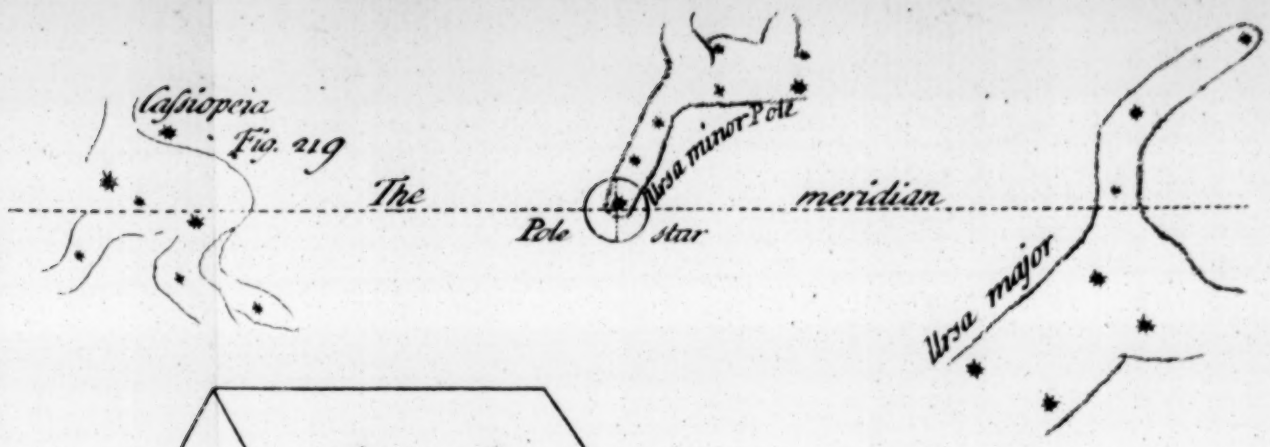

Fig. 219

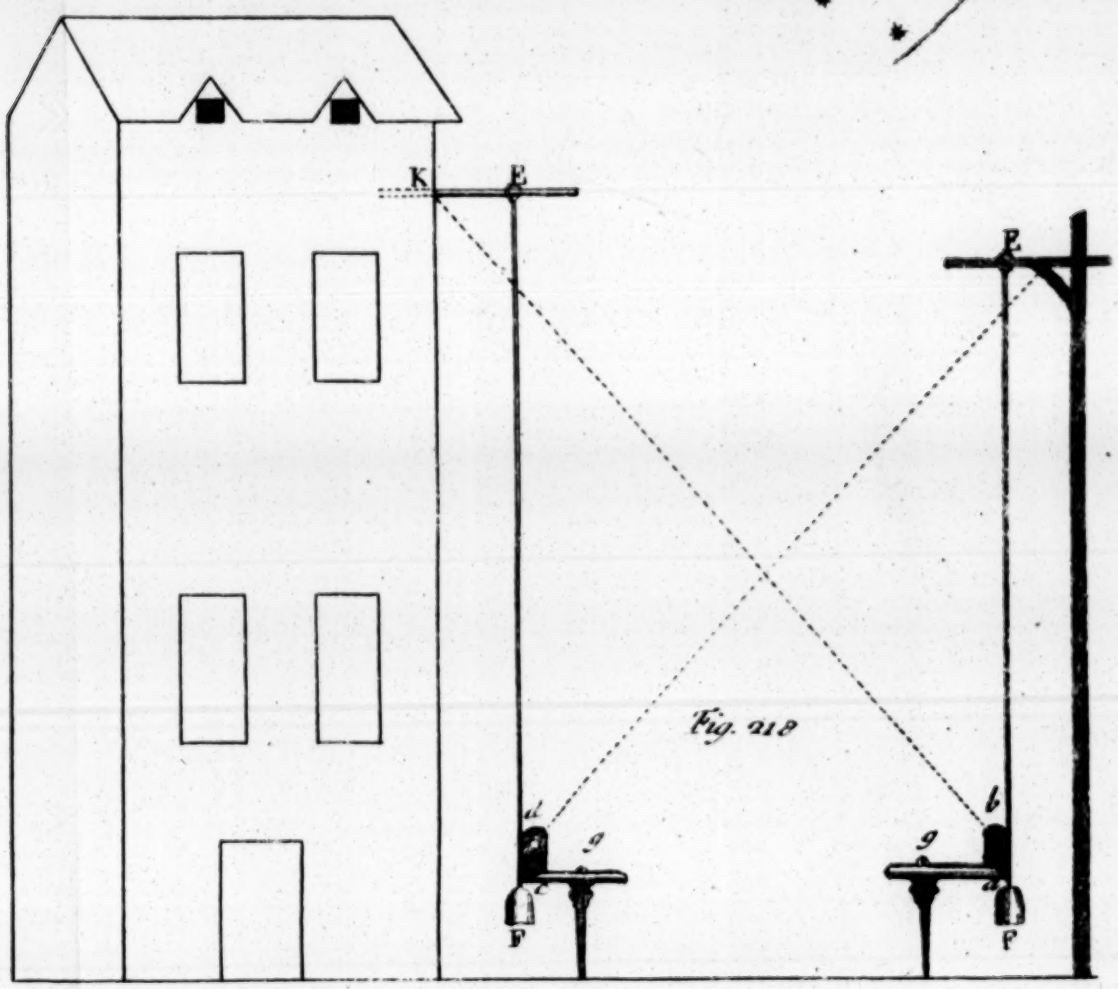

Fig. 218

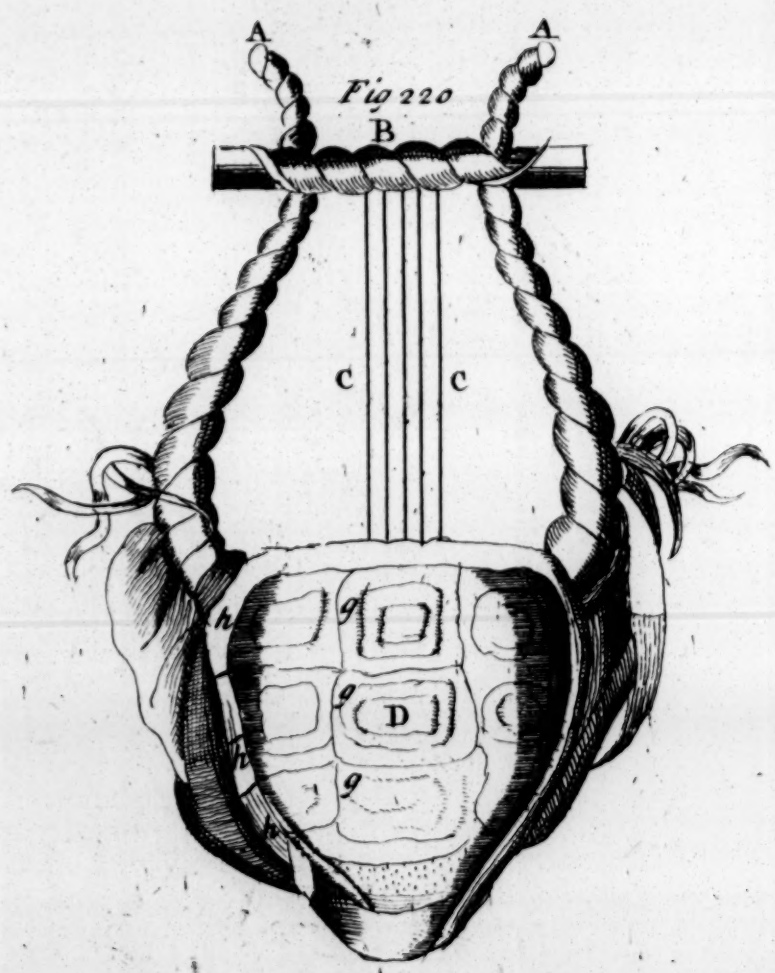

Fig 220

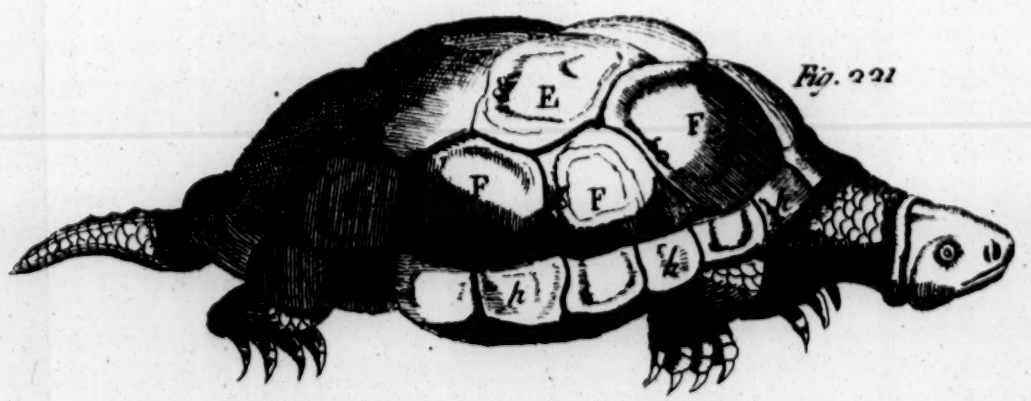

Fig. 221

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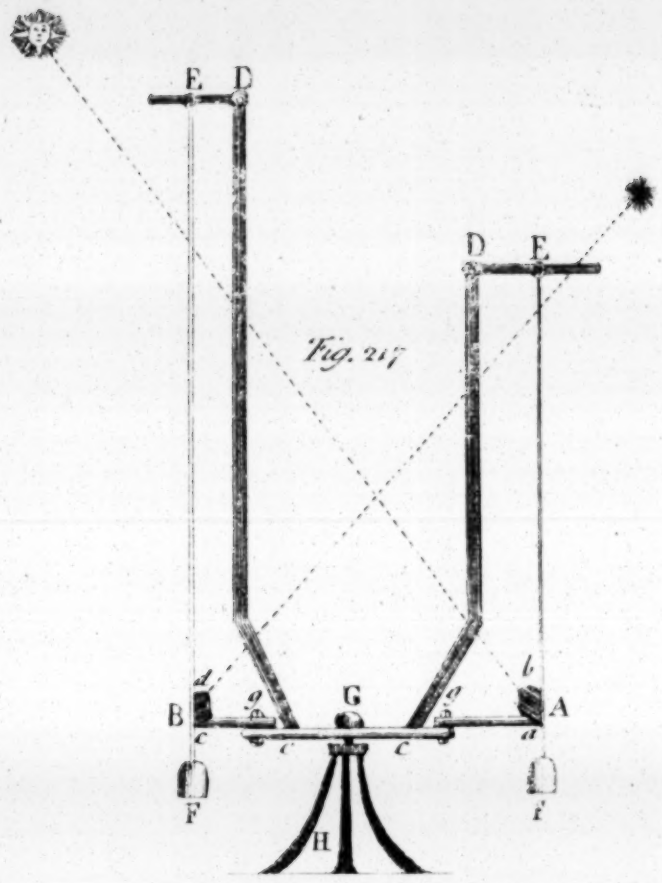
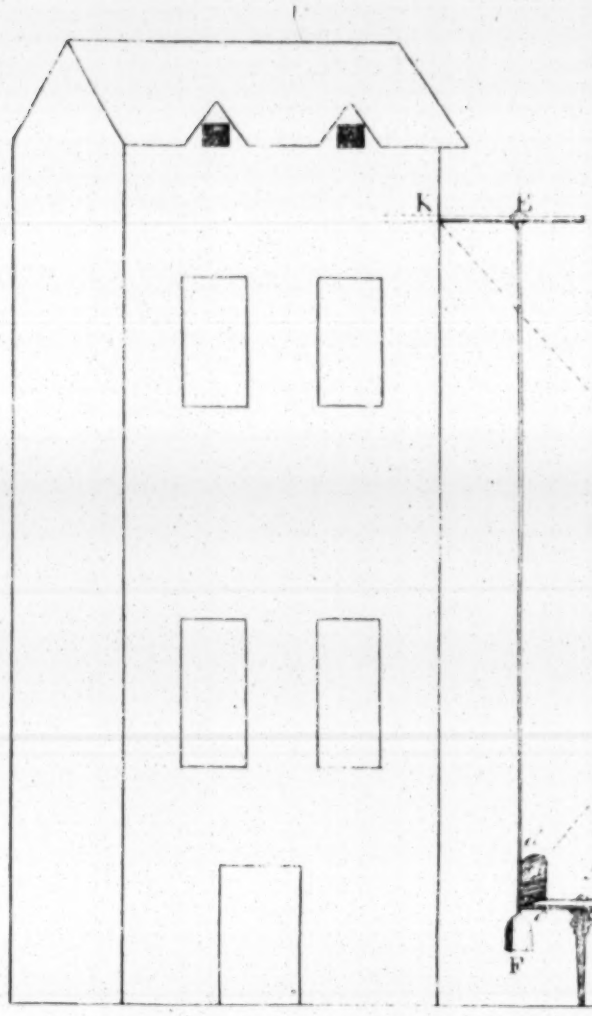
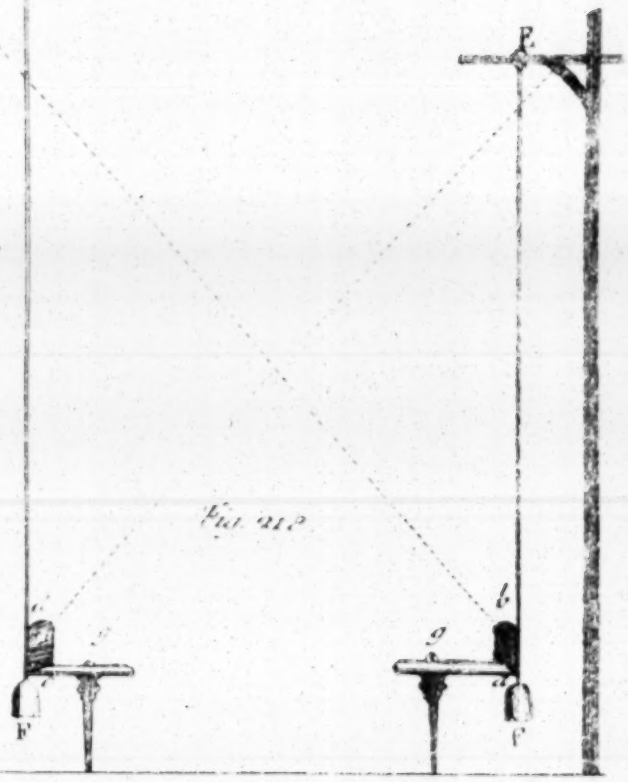


Fig. 217





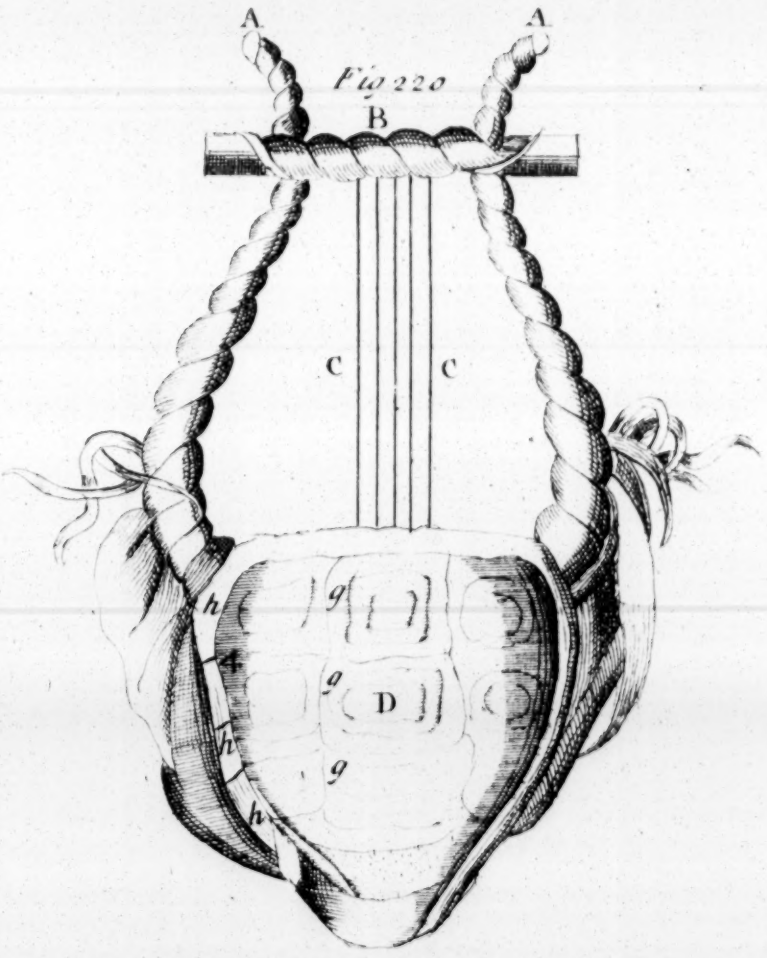


Fig. 220

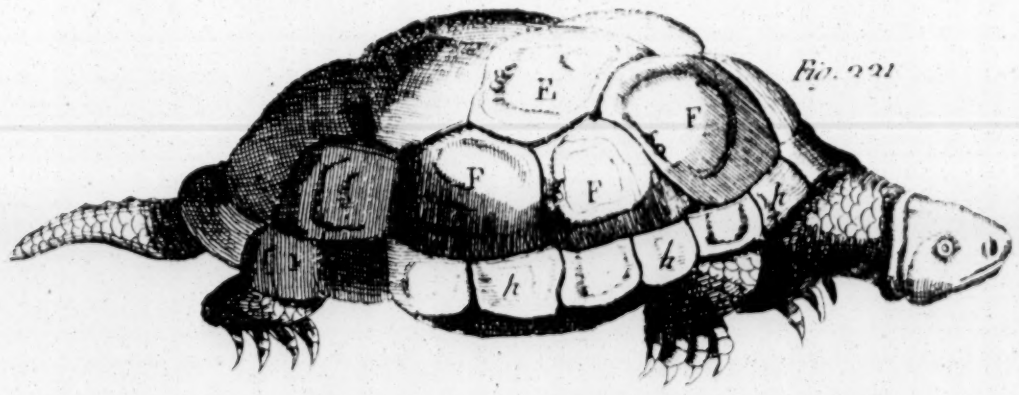


Fig. 221

Thus turn'd by *Joannes Gorræus*,

Cum curvâ auxilio veniunt Teſtudine ——
Quæ Pelagi fluctus velocibus innàtat alis,
Aut montana etiam Cytiſo quæ veſcitur, & quam
Reddidit e muta modulanti voce canoram
Mercurius, picto inſontis qui Cortice carnem
Exemit, geminumq; Ancona intendit in oris.

Grevinus in his Treatiſe *de Venenis* in the Chapter *de Salamandra*, pag. 119. gives us a Comment on theſe Verſes, and relates at large the Hiſtory of the firſt Lyre, but I cannot but take Notice that this Verſe

Αυδήεσσαν ἔθηκεν ἀναύδητόν περ ἐοῦσαν;

Reddidit e muta modulanti voce canoram —— Is ſo home and appoſite to our Purpoſe, and comes up ſo cloſe to *Horace*'s Thought,

O mutis quoque Piſcibus
Donatura Cygni ſi libeat ſonum,

that it does not only explain the true Meaning of it, but makes me inclinable to believe that *Horace* might have in his View this very Paſſage; which he ſeems alſo again to allude to (though not ſo fully and expreſly) in his 11*th* Ode of the 3*d* Book, where he invokes his Lyre,

Tuq; Teſtudo reſonare ſeptem
Callida nervis,
Nec Loquax olim neque grata ——

The other Inſtance is from one of *Lucian*'s Dialogues, who writ above a hundred Years after *Horace*; whence 'tis plain the Mechaniſm of the ancient Lyre, and the Opinion concerning its firſt Invention, prevail'd ſince, as well as before, *Horace*'s Days. In this Dialogue he introduces *Apollo* and *Vulcan* talking after his jocoſe way of *Mercury* to this Purpoſe.

Απ. χελώνην ποτὲ νεκρὰν εὑρών, ὄργανον ἀπ' αὐτῆς σωσεπήξαλο, πήχεις δὲ ἐναρμόσας, καὶ ζυγώσας, ἔπειτα καλάμους ἐμπήξας, καὶ μαγάδιον ὑποθεὶς, καὶ ἐντεινάμενος ἕπτα χόρδας, μελῳδεῖ πάνυ γλαφυρὸν, ὦ Ηφαιστε, καὶ ἐναρμόνιον.

Ap. *Teſtudinem mortuam alicubi offendens Inſtrumentum ex ea concinnavit; Brachia enim adaptans Jugum oppoſuit, deinde Clavos infigens, & Hæmiſphærium repandum infra ſubjiciens, ſeptem Chordas extendebat, atq; modulabatur quiddam valde ſonorum, O Vulcane, & ad Muſicæ Melodiam compoſitum.*

Fig. 220. is taken from Father *Merſennus* (*Lib.* 1. *de* Inſtrumentis, *p.*7.) which he tells us he copied from the Sculpture of an antique Gem, that belong'd to one *Jacobus Gaffarellus*. *A*, *A*, ſhew the πήχεις of *Lucian*, the Ἀγκῶνες or *Brachia* of *Nicander*, made of the Horns of ſome Beaſt. *B* the Ζύγον, or *Jugum*, in which were faſtened the κάλαμοι *Clavi*, Pegs that raiſed or depreſt *c*, *c*, the χόρδαι, or Strings, which were fix'd at their t'other End to *D* the μαγάδιον *Hemiſphærium* or Belly: This is very like *Figure* 221. which is an entire *Teſtudo Aquatica* or rather *Fluviatilis*, taken from *Johnſtonus de Animalibus* as delineated in his *eightieth* Table *de Quadrupedibus*; making Allowances for their different Poſture, one being repreſented full and flat, whilſt only half of the other appears becauſe 'tis ſhewn ſide-ways. Fig. 220. Fig. 221.

Fig. 220. The Belly of *Merſennus*'s Lyre mark'd *D*, agrees nicely in Figure and Shape with the Back or Shell of *Johnſtonus*'s *Teſtudo Aquatica*, mark'd *E*.

Fig. 221. They are both curiouſly teſſelated, checker'd into Areas or Scales *F*, *F*, *F*, *F*, *F*, *F*, of ſomewhat a Square Figure; and each of theſe Scales again in both is neatly wrought about their Edges with a Line running parallel to their Margins *g*, *g*, *g*, *g*, *g*, *g*; and the Shell of the Lyre, as that of Tortoiſe, terminates in a narrow Limb or Verge, cut into ſmaller Scales *h*, *h*, *h*, *h*, *h*, *h* incompaſſing the whole; ſo that both theſe Figures though drawn by different Artiſts, perhaps at two thouſand Years Diſtance, do manifeſtly own the Lineaments of the ſame natural Original.

Pauſanias too in his Deſcription of *Greece* (as I find it quoted by *Geſner*) mentions a Mountain in *Arcadia* called *Parthenius Mons, qui Teſtudines exhibet ad compingendas Lyras aptiſſimas*; and in another Place, *Arcadum Querceta ingenti magnitudine Teſtudines exhibent, ex quibus Lyras conficeres æquales illis quæ ex Indica Teſtudine componuntur.* From whence 'tis plain the Ancients made their *Lyres* of the Shells of *Tortoiſes*, perhaps not very curious in the Choice of their Materials, but might take promiſcuouſly the *Land* or *River Tortoiſe*, which occaſions *Pauſanias* and *Nicander* to mention the *Mountain*, whereas *Horace* ſpeaks of the *River Tortoiſe*.

And indeed moſt of the Inſtruments, *&c.* now in Uſe were at firſt rude, plain, and ſimple, tho' improv'd by Length of Time, and Fancy of Artificers: Thus the *Flute*, *Flagelet*, *Hautboy*, and *Organs*, are only Improvements of the *Tenues Avenæ* or *Oaten-Pipes* of the Field, or the *Calami impares Juncti* of the Ancients, *Reeds* of unequal Lengths rudely put together; thus their Trumpets were at firſt made only of rude *Horns* of Beaſts, and ſometimes of the common *Buccina Whelks* or large Sea-ſhells, hence *Virgil*,

Rauco ſtrepuerunt Cornua cantu. And *Perſius*,
Buccina jam priſcos cogebat ad arma Quirites.

And thus their Lyres were at firſt made of the Tortoiſe Shell; tho' in after Ages the Number of the Strings was encreaſed, and the Model alter'd; and the Inſtrument tho' improv'd, and very unlike its firſt Original, yet ſtill retain'd its Ancient Name.

This appears from thoſe other Schemes *Merſennus* gives in the ſame Table of ſeveral Sorts of the ancient Lyres (but theſe I take to be more Modern than that which is here expreſt) and from thoſe deſcrib'd by *Leonardo Agoſtini*, in the Second Part of his Collection of the *Gemme Antiche*, which ſhew us, that as the Fancy of the Workman, the Mode of the Times, real Convenience or an imaginary Beauty in the Inſtrument determin'd it, they were faſhion'd into various Shapes, and frequently like their Lamps of Old into capricious, fantaſtical odd Figures.

The End of the FIRST PART.

THE PHILOSOPHICAL TRANSACTIONS ABRIDG'D.

PART II.

CONTAINING THE

PHYSIOLOGICAL PAPERS.

CHAP. I.

Physiology. Meteorology. Pneumatics.

0 | I. CALOR aeris hyberni ubi aqua incipit gelu rigeſcere. Innoteſcit hic calor accuratè locando Thermometrum in nive compreſſâ, quo tempore gelu ſolvitur. *A Scale of the Degrees of Heat, by .... n. 270. p. 824.*

0, 1, 2. | Calores aeris hyberni.

2, 3, 4. | Calores aeris verni & autumnalis.

4, 5, 6. | Calores aeris æſtivi.

6. | Calor aeris meridiani circa menſem Julium.

12. | 1 | Calor maximus quem Thermometer ad contactum corporis humani concipit. Idem circiter eſt calor avis ova incubantis.

Calor

14 $\frac{3}{11}$	1 $\frac{1}{4}$	Calor balnei prope maximus quem quis manu immerſâ & conſtanter agitatâ diutiùs perferre poteſt. Idem fere eſt calor ſanguinis recens effuſi.
17	1 $\frac{1}{4}$	Calor balnei maximus quem quis manu immerſâ & immobili manente diutiùs perferre poteſt.
20 $\frac{2}{11}$	1 $\frac{3}{4}$	Calor balnei quo cera innatans & liquefacta deferendo rigeſcit & diaphaneitatem amittit.
24	2	Calor balnei quo cera innatans incaleſcendo liqueſcit, & in continuo fluxu ſine ebullitione conſervatur.
28 $\frac{6}{11}$	2 $\frac{1}{4}$	Calor mediocris inter calores quo cera liqueſcit & aqua ebullit.
34	2 $\frac{1}{2}$	Calor quo aqua vehementer ebullit & miſtura duarum partium plumbi, trium partium ſtanni & quinque partium biſmuti defervendo rigeſcit. Incipit aqua ebullire calore partium 33 & calorem partium pluſquam 34 $\frac{1}{2}$ ebulliendo vix concipit. Ferrum verò deferveſcens calore partium 35 vel 36, ubi aqua calida, & 37, ubi frigida in ipſum guttatim incidit, deſinit ebullitionem excitare.
40 $\frac{4}{11}$	2 $\frac{3}{4}$	Calor minimus quo miſtura unius partis Plumbi quatuor partium Stanni & quinque partium biſmuti incaleſcendo liqueſcit, & in continuo fluxu conſervatur.
48	3	Calor minimus quo miſtura æqualium partium ſtanni & biſmuti liqueſcit. Hæc miſtura calore partium 47 defervendo coagulatur.
57	3 $\frac{1}{4}$	Calor quo miſtura duarum partium ſtanni & unius partis biſmuti funditur, ut & miſtura trium partium ſtanni & duarum plumbi: ſed miſtura quinque partium ſtanni & duarum partium biſmuti hoc calore defervendo rigeſcit. Et idem facit miſtura æqualium partium plumbi & biſmuti.
68	3 $\frac{1}{2}$	Calor minimus quo miſtura unius partis biſmuti & octo partium ſtanni funditur. Stannum per ſe funditur calore partium 72 & Defervendo rigeſcit calore partium 70.
81	3 $\frac{3}{4}$	Calor quo biſmutum funditur ut & miſtura quatuor partium plumbi & unius partis ſtanni. Sed miſtura quinque partium plumbi & unius partis ſtanni, ubi fuſa eſt & defervet in hoc calore, rigeſcit.
96	4	Calor minimus quo plumbum funditur. Plumbum incaleſcendo funditur calore partium 96 vel 97 & defervendo rigeſcit calore partium 95.
114	4 $\frac{1}{4}$	Calor quo corpora ignita defervendo penitus deſinunt in tenebris nocturnis lucere, & viciſſim incaleſcendo incipiunt in iiſdem tenebris lucere, ſed luce tenuiſſima quæ ſentiri vix poſſit. Hoc calore liqueſcit miſtura æqua-

		æqualium partium Stanni & Reguli Martis, & miſtura ſeptem partium biſmuti & quatuor partium ejuſdem Reguli defervendo rigeſcit.
136	$4\frac{1}{2}$	Calor quo corpora ignita in tenebris nocturnis candent, in crepuſculo vero neutiquam. Hoc calore tum miſtura duarum partium reguli martis & unius partis biſmuti, tum etiam miſtura quinq; partium Reguli Martis & unius partis Stanni defervendo rigeſcit. Regulus per ſe rigeſcit calore partium 146.
161	$4\frac{3}{4}$	Calor quo corpora ignita in crepuſculo proximè ante ortum ſolis vel poſt occaſum ejus manifeſtò candent, in clara verò diei luce neutiquam, aut non niſi perobſcure.
192	5	Calor prunarum in igne parvo culinari ex carbonibus foſſilibus bituminoſis conſtructo & abſq; uſu follium ardente. Idem eſt calor ferri in tali igne quantum poteſt candentis. Ignis parvi culinaris qui ex lignis conſtat, calor paulo major eſt, nempe partium 200 vel 210. Et ignis magni major adhuc eſt calor, præſertim ſi follibus cieatur.

In hujus Tabulæ columna prima habentur gradus caloris in proportione arithmetica computum inchoando a calore, quo aqua incipit gelu rigeſcere, tanquam ab infimo caloris gradu ſeu communi termino caloris & frigoris, & ponendo calorem externum corporis humani eſſe partium duodecim. In ſecunda columna habentur gradus caloris in ratione geometrica, ſic ut ſecundus gradus ſit duplo major primo, tertius item ſecundo, & quartus tertio, & primus ſit calor externus corporis humani ſenſibus æquatus. Patet autem per hanc Tabulam, quod calor aquæ bullientis ſit fere triplo major quam calor corporis humani, & quod calor ſtanni liqueſcentis ſit ſextuplo major, & calor plumbi liqueſcentis octuplo major, & calor Reguli liqueſcentis duodecuplo major, & calor ordinarius ignis culinaris ſexdecim vel ſeptemdecim vicibus major, quam calor idem corporis humani.

Conſtructa fuit hæc Tabula ope Thermometri & Ferri candentis. Per Thermometrum inveni menſuram calorum omnium uſq; ad calorem quo ſtannum funditur & per ferrum caleſactum inveni menſuram reliquorum. Nam calor quem ferrum caleſactum corporibus frigidis ſibi contiguis dato tempore communicat, hoc eſt, calor quem ferrum dato tempore amittit, eſt ut calor totus ferri. Ideoque ſi tempora refrigerii ſumantur æqualia, calores erunt in ratione geometrica, & propterea per tabulam logarithmorum facilè inveniri poſſunt.

Primùm igitur per Thermometrum ex oleo lini conſtructum inveni, quod ſi oleum, ubi Thermometer in nive liqueſcente locabatur, occupabat ſpatium partium 10000; idem oleum calore primi gradus ſeu corporis humani rarefactum occupabat ſpatium 10256, & calore aquæ jamjam ebullire incipientis ſpatium 10705, & calore aquæ vehementer ebullientis

bullientis ſpatium 10725 & calore ſtanni liquefacti defervientis ubi incipit rigeſcere & conſiſtentiam amalgamentis induere, ſpatium 11516 & ubi omnino rigeſcit ſpatium 11496. Igitur oleum rarefactum fuit ad dilatatum in ratione 40 ad 39, per calorem corporis humani; in ratione 15 ad 14 per calorem aquæ bullientis; in ratione 15 ad 13, per calorem ſtanni defervientis ubi incipit coagulari & rigeſcere; & in ratione 23 ad 20, per calorem quo ſtannum deferviens omnino rigeſcit. Rarefactio aeris æquali calore fuit decuplo major quam rarefactio olei, & rarefactio olei quaſi quindecim vicibus major quàm rarefactio ſpiritus vini. Et ex his inventis ponendo calores olei ipſius rarefactioni proportionales & pro calore corporis humani ſcribendo partes 12, prodiit calor aquæ ubi incipit ebullire, partium 33, & ubi vehementiùs ebullit, partium 34; & calor ſtanni ubi vel liqueſcit vel deferviendo incipit rigeſcere & conſiſtentiam amalgamatis induere prodiit, partium 72, & ubi defervendo rigeſcit & induratur, partium 70.

His cognitis, ut reliqua inveſtigarem, calefeci ferrum ſatis craſſum donec ſatis canderet, & ex igne cum forcipe etiam candente exemptum locavi ſtatim in loco frigido, ubi ventus conſtanter ſpirabat; & huic imponendo particulas diverſorum metallorum & aliorum corporum liquabilium, notavi tempora refrigerii, donec particulæ omnes, amiſſâ fluiditate, rigeſcerent, & calor ferri æquaretur calori corporis humani. Deinde ponendo quod exceſſus calorum ferri & particularum rigeſcentium ſupra calorem atmoſphæræ Thermometro inventum eſſent in progreſſione geometrica, ubi tempora ſunt in progreſſione Arithmetica, calores omnes innotuere. Locavi autem ferrum, non in aere tranquillo, ſed in vento uniformiter ſpirante, ut aer a ferro calefactus ſemper abriperetur a vento, & aer frigidus in locum ejus uniformi cum motu ſuccederet. Sic enim aeris partes æquales æqualibus temporibus calefactæ ſunt, & calorem conceperunt calori ferri proportionalem.

Calores autem ſic inventi eandem habuerunt rationem inter ſe cum caloribus per Thermometrum inventis, & propterea rarefactiones olei ipſius caloribus proportionales eſſe rectè aſſumpſimus.

An Account of Dr. Hook's *Marine Barometer, by Mr.* E. Halley. n. 269. p. 791.

II. Dr. *Hook*, who has made many Attempts to improve the *Barometer*, and to render the minute Diviſions on the Scale thereof more ſenſible, judging that it might be of great Uſe at Sea, contrived ſeveral Ways to make it ſerviceable on Board of Ship; one of which he explained to the *Royal Society* at their weekly Meeting in *Greſham-College*, *January* 2. 166$\frac{7}{8}$. ſince which Time he hath further cultivated the Invention, and ſome Years ago produced before the ſaid *Society*, the Inſtrument I am now to deſcribe.

The Mercurial Barometer requiring a perpendicular Poſture, and the Quick-ſilver vibrating therein with great Violence upon any Agitation, is therefore uncapable of being uſed at Sea, (though it hath lately

lately been contrived to be made portable.) So it remained to find out ſome other Principle, wherein the Poſition of the Inſtrument was not ſo indiſpenſably neceſſary: For this, all thoſe that uſe the Sea are obliged to the great Facility Dr. *Hook* has always ſhewn, in applying Philoſophical Experiments to their proper Uſes.

It is about 40 Years ſince, that the *Thermometers* of *Robt. de Fluctibus*, depending on the Dilatation and Contraction of included Air by Heat and Cold, have been diſuſed, upon Diſcovery that the Air's Preſſure is unequal; that Inequality mixing itſelf with the Effects of the Warmth of the Air in that Inſtrument. And inſtead thereof was ſubſtituted the ſeal'd Thermometer, including Spirit of Wine (firſt brought into *England* out of *Italy* by Sir *Robert Southwell*) as a proper Standard of the Temper of the Air in relation to Heat and Cold; that æthereal Spirit being of all the known Liquors the moſt ſuſceptible of Dilatation and Contraction eſpecially with a moderate Degree of either Heat or Cold. Now this being allowed as a Standard, and the other Thermometer that includes Air being graduated with the ſame Diviſions, ſo as at the Time when the Air was included, to agree with the Spirit-Thermometer in all the Degrees of Heat and Cold, noting at the ſame Time the preciſe Height of the Mercury in the common Barometers: It will readily be underſtood, that whenſoever theſe two Thermometers ſhall agree, the Preſſure of the Air is the ſame it was, when the Air was included and the Inſtrument graduated: That if in the Air-Thermometer the Liquor ſtand higher than the Diviſion marked thereon, correſponding with that on the Spirit-Glaſs, it is an Indication that there is a greater Preſſure of the Air at that Time, than when the Inſtrument was graduated. And the contrary is to be concluded, when the Air-Glaſs ſtands lower than the Spirit, *viz.* that then the Air is ſo much lighter, and the Quick-ſilver in the ordinary Barometers lower than at the ſame Time of Graduation.

And the Spaces anſwering to an Inch of Mercury will be more or leſs, according to the Quantity of Air ſo included, and the Smallneſs of the Glaſs Cane, in which the Liquor riſes and falls, and may be augmented almoſt in any Proportion, under that of the ſpecifick Gravity of the Liquor of the Thermometer to Mercury. So as to have a Foot or more for an Inch of Mercury, which is another great Convenience.

It has been obſerved by ſome, that in long keeping this Inſtrument, the Air included either finds a Means to eſcape, or depoſits ſome Vapours mix'd with it, or elſe for ſome other Cauſe becomes leſs Elaſtick, whereby in Proceſs of Time it gives the Height of the Mercury ſomewhat greater than it ought; but this, if it ſhould happen in ſome of them, hinders not the Uſefulneſs thereof, for that it may at any Time very eaſily be corrected by Experiment, and the riſing and falling thereof are the Things chiefly remarkable in it, the juſt Height being barely a Curioſity.

In theſe Parts of the World, long Experience has told us, that the riſing of the Mercury forebodes fair Weather after foul, and an Eaſterly or Northerly Wind, and that the falling thereof, on the contrary, ſignifies Southerly or Weſterly Winds, with Rain, or ſtormy Winds, or both; which latter is of much more Conſequence to provide againſt at Sea than at Land; and in a Storm, the Mercury beginning to riſe, is a ſure Sign that it begins to abate, as has been experienced in high Latitudes both to the Northwards and Southwards of the Equator.

Fig. 1. *A B* repreſents the Spirit-Thermometer, graduated from o, or the freezing Point, through all the poſſible Degrees of the Heat or Cold of the Air, at leaſt in theſe Climates.

C D is the Air-Thermometer, graduated after the ſame Manner, with the like Degrees.

E F is a Plate applied to the Side of the Thermometer *C D*, graduated into Spaces anſwering to Inches and Parts of an Inch of Mercury, in the Common Barometers.

G, a Hand ſtanding on the Plate at the Height of the Mercury thereon, as it was when the Inſtrument was graduated, as ſuppoſe here at 29 $\frac{1}{2}$ Inches.

L M a Wire on which the Plate *E F* ſlips up and down, parallel to the Cane of the Thermometer *C D*.

K, any Point at which the Spirit ſtands at the Time of Obſervation; ſuppoſe at 38 on the Spirit-Thermometer; ſlide the Plate *E F* till the Hand *G* ſtand at 38 on the Air-Thermometer, and if the Liquor therein ſtand at 38 likewiſe, then is the Preſſure of the Air the ſame as at the Time of Graduation; *viz.* 29, 5; but if it ſtand higher, as at 30 at I, then is the Preſſure of the Air greater; and the Diviſion on the ſliding Plate againſt the Liquor, ſhews the preſent Height of the Mercury to be 29 Inches 7 Tenths.

I had one of theſe Barometers with me in my late Southern Voyage, and it never failed to prognoſtick and give early Notice of all the bad Weather we had.

A New *Baroſcope by Mr.* Caſwell, n. 290. p. 1597.

III. I have made a new Sort of Baroſcope, 'tis cheap and very exact, I here ſend you its Calculation as it occur'd to my Thoughts before I made it. Suppoſe *A B C D* is a Bucket of Water, in it the Baroſcope *x r e z y o s m* which conſiſts of a Body *x r s m*, and a Tube *e z y o*, the Body and Tube are both concave Cylinders communicating with each other, and made of Tin (for Want of Glaſs:) The Bottom of the Tube *z y* has a Lead-weight to ſink it, ſo that the Top of the Body may juſt ſwim even with the Surface of the Water by the Addition of ſome Grain-Weights on the Top. The Water when the Inſtrument is forced with its Mouth downwards gets up into the Tube to the Height *y u*. There is added on the Top a ſmall concave Cylinder, which I call the Pipe, to diſtinguiſh it from the Bottom

Fig. 2.

ſmall

ſmall Cylinder, which I call the Tube: This Pipe is to ſuſtain the Inſtrument from ſinking to the Bottom, *m d* is a Wire, *m S*, *d E* are two Threads oblique to the Surface of the Water, which Threads perform the Office of Diagonals: For that while the Inſtrument ſinks more or leſs by the Alteration of the Gravity of the Air, there, where the Surface of the Water cuts the Thread, is form'd a ſmall Bubble, which Bubble aſcends up the Thread, while the ☿ of the common Baroſcope aſcends.

The Circumference of the Body is 21 Inches, therefore its Area = 35: the Altitude *m s* = 4, therefore the Body's Solidity = 140, each Baſe *x m*, *r s*, has a Convexity whoſe Altitude is 6.5, therefore the Conoid on each Baſe is nearly = $11\frac{1}{2}$, therefore *d* the whole Body is = (140 + $11\frac{1}{2}$ + $11\frac{1}{2}$ =) 163, and *b* the entire Altitude of the Body = (4 + .65 + .65 =) 5.3. The Inner Circumference of the Tube is 5.014, therefore its Area *n* = 2 the Length of the Tube = 45, therefore the Tube's Capacity = 9, therefore *C*, the Content of the Body and Tube = 163 + 9 = 172 Cubic Inches, that is almoſt $2\frac{1}{2}$ Quarts.

Suppoſe the Air's Preſſure when greateſt = 30.5 Inches of ☿ = (30.5 × 14 =) 427 of Water, and *f* = 427, therefore *f c* = 73444. Put *a* for the Depth *o u*, of the Air in the Tube when the Body is juſt all immerſed, the Air in the Inſtrument on Immerſion contracts ſomewhat by the Cold of the Water; this Contraction I find is nearly as much as would be produc'd by an Addition of 1 Inch to the Atmoſphere's Altitude 427; this in cold Weather, but in warm Weather 'tis probably twice as much: But we will now ſuppoſe it = 1, therefore the Depth of the Surface of the Water in the Tube below the Surface of the outer Water is = *b* + *a*, therefore the Preſſure on that inner Surface, is as the Altitude of the Atmoſphere above it = *f* + *b* + 1 + *a* = *F* − *a* (putting *F* = *f* + *b* + 1.) Then for that the Spaces into which the Air is contracted, are reciprocal to their reſpective Preſſures, and for that while the Inſtrument is out of the Water, the Preſſure *f* anſwered to the Space *C* therefore,

$F + a : f :: C : \frac{f c}{F + a}$ = Space which the Air takes up in the Inſtrument under Water; therefore, $\frac{f c}{F + a} - d$ = that Part of the Tube which is poſſeſſed by Air = *a n* (ſuppoſing the Tube's Area 2 = *n*).

Therefore $f c - F d - a d = F a n + a a n$. Therefore $a a + F + \frac{d}{n}$

$\times a = \frac{f c - F d}{n}$. Put $F + \frac{d}{n} = 2 g$, therefore $a a + 2 g a$, $= \frac{f c - F d}{n}$ therefore $a = \sqrt{:\frac{f c - F d}{n} + g g} - g$.

Then ſuppoſe the Atmoſphere's Gravity leſs, ſo much as to ſink the ☿ $\frac{1}{10}$ Inch $= 1.4$ of Water, and therefore putting $\phi = F - 1.4$, and in the laſt Equation α inſtead of a, and γ inſtead of g, you have $\alpha = \sqrt{\frac{f c - \phi d}{n} + \gamma\gamma} : - \gamma$. Thus I find $a = 2.72$ / $\alpha = 2.94$ } and therefore $\alpha - a = .22$, which $.22 \times n$ gives .44 Cubic Inches, and (ſuppoſing a Cube-Inch $= 253$ Grains) $.44 \times 253 = 111$ Grains Weight of Water that was gotten up into the Tube in the firſt Caſe more than in the ſecond, and therefore the Baroſcope requires an Addition of 111 Grains on its Top to ſink it with the Level of the Water in the ſecond Caſe more than in the firſt, and this upon the ſinking of the ☿ in the common Baroſcope only $\frac{1}{10}$ Inch; now 1 Grain in this new Baroſcope is nearly as diſcernable as $\frac{1}{10}$ Inch in the common, and therefore this new Baroſcope is more exact than the common 111 Times.

Put $f = 247$ $.c = 172$ $.d = 163$ $.n = 2$ as above, only change F, put F, put F 437.3, that is, ſuppoſe the Body ſunk in Water 4 Inches lower; in this Caſe $\alpha = 208$, therefore $a - \alpha = .64$, which multiplied into $\phi n = 1.28$ Cubic-Inches, which $\times 253$ gives 324 Grains, and ſo much the Body's Top $x m$ being ſunk 4 Inches under Water, the Body becomes heavier, than while $x m$ was at the Surface of the Water. Therefore this 1.28 divided by the aforeſaid Depth 4 gives .32 the Area of the Top-Pipe, ſuch as would ballance or buoy up the Body at any Depth. Strictly ſpeaking, the Pipe ſhould be gradually bigger upward in order to ſuſtain the Inſtrument at any Depth, but as to Senſe it is Cylindrical, and its Circumference $= 2.005$. But for that the leaſt Alteration of the Air, would make the Body's Top $x m$ in that Caſe paſs through the 4 Inches (which 4 Inches I ſuppoſe, all the Variety of Depth that the Inſtrument has room given it in the Bucket to aſcend or deſcend) therefore the Pipe is made a ſmall Matter bigger, *(viz.)* its Circumference is 2.14; whereby the Pipe, according as the Body ſinks more, gives more Reſiſtance to the deſcending Body. The Pipes Area is .3643; therefore the Capacity of the Pipe in 4 Inches Altitude is $= 1.457$. But as aboveſaid to give juſtly no Reſiſtance, its Capacity ſhould be 1.28. Therefore this 1.28 taken from 1.457, leaves .177 the actual Reſiſtance in 4 Inches Depth, *viz.* $(.177 \times 253 =)$ 44 Grains.

But

But this Reſiſtance will not be the ſame in all Weathers, in order therefore to calculate what it will be when the ☿ of the common Baroſcope is very low: For Example, but 28 Inches high = 392 of Water; f muſt be ſuppoſed=392, therefore $F=f+b+1=398.3$, and the reſt as before; *viz.* $d=163$, $fc=67424$. $Fd=649229$. thence by the aforeſaid Equation $\left.\begin{matrix} a=2.59 \\ \alpha=2.84 \end{matrix}\right\}$ therefore $\alpha - a = .25$, which × n gives .50 Cubic Inches, which × 253 = 126 Grains. So that this Baroſcope when the ☿ is loweſt, is more exact than the common 126 Times, ſuppoſing the Body immerſed afreſh when the ☿ is ſo low.

Next while the ☿ is ſo very low, ſuppoſe the Top of the Body depreſs'd 4 Inches under Water; therefore $\phi = F+4 = 402.3$, the reſt are as before, *viz.* $fc = 67424$, then α will be 19: but before, while the Top of the Body was at the Surface, α was 2.59; therefore the Difference 69 × Tube's Area 2, gives 1.38 Cube-Inches, which × 253 gives 349 Grains, and ſo much the Baroſcope is heavier, when the Top $x\,m$ is 4 Inches under Water; or which comes to the ſame, ſuppoſing that ☿ at 28, and $x\,m$ at the Surface; this Baroſcope by the ☿'s aſcending $\frac{4}{14}$ Inch will become heavier 349 Grains. The Pipe's Capacity in 4 Inches Altitude was 1.457, from which take the aboveſaid 1.38, the Reſidue = .077, which × 253 gives 19 Grains in 4 Inches; ſo that the Pipe will ſuſtain the Baroſcope, and alſo 44 when the ☿ is $30\frac{1}{2}$ high, and but 19 Grains when the ☿ is 28 high. The fewer Grains Difference there are in its ſinking, through 4 Inches, the more nice the Baroſcope will be.

There where the Thread cuts the Surface of the Water, is form'd a Bubble, therefore this Bubble while the Inſtrument ſinks in Water 4 Inches, which is all the room that I give it, the Bubble moves on the 2 Diagonal Threads 20 Inches, it follows therefore that 120 Grains Difference would make the Bubble walk over 120 Inches, if the Threads were ſo long, but as it has been above calculated, about 120 Grains Difference of Weight of the Inſtrument is produc'd by ſo much of the Alteration of the Air, as would make the ☿ of the common Baroſcope $\frac{1}{10}$ Inch; therefore when the ☿ aſcends $\frac{1}{10}$ Inch, the Bubble of this new Baroſcope aſcends 120 Inches; therefore this new Baroſcope is more exact than the common Baroſcope by about 1200 Times.

Obſervations made with this Baroſcope.

1. While the ☿ of the common Baroſcope is often known to be ſtationary 24 Hours together, the Bubble of the new Baroſcope is rarely found to ſtand ſtill one Minute.

2. Suppoſe the Air's Gravity encreaſing, and accordingly the Bubble aſcending, during the Time that it aſcends 20 Inches, it will have many ſhort Deſcents, of the Quantity of $\frac{1}{2}$ Inch 1, 2, 3, or more Inches, each of which being over it will aſcend again. Theſe Retroceſſions are frequent, and of all Varieties in Quantity and Duration, ſo that there is no judging of the general Courſe of the Bubble by bare Inſpection, though you ſee it moving but by waiting a little Time.

3. A

3. A ſmall Blaſt of Wind will make the Bubble deſcend; a Blaſt that cannot be heard in a Chamber of the Town, will ſenſibly force the Bubble downward. The Blaſts of Wind ſenſible abroad cauſe many of the aboveſaid Retroceſſions, or Accelerations in the general Courſe; as I found by carrying my Baroſcope to a Place where the Wind was perceptible.

4. Clouds make the Bubble deſcend. A ſmall Cloud approaching to the Zenith, works more than a great Cloud near the Horizon. In cloudy Weather the Bubble deſcending, a Break of the Clouds (or clear Place) approaching to the Zenith, has made the Bubble to aſcend; and after that Break had paſſed beyond the Zenith a conſiderable Space, the Bubble again deſcended.

5. All Clouds (except one) hitherto by me obſerved, have made the Bubble to deſcend. But the other Day the Wind being *North*, and the Courſe of the Bubble deſcending, I ſaw to the Windward a large thick Cloud near the Horizon, and the Bubble ſtill deſcended, but as this Cloud drew near the Zenith, it turned the Way of the Bubble, making it to aſcend, and the Bubble continued aſcending till the Cloud was all paſſed, after which it reſumed its former Deſcent. It was a Cloud that yielded a cold Shower of ſmall Hail.

An Account of a New Thermometer, *by Mr.* Geoffroy. n. 274. p. 961, 962.

IV. This New Thermometer is compos'd of a Bowl or Bottle of Glaſs, *A*, which has no other opening, but by a little Tunnel at the End; and which deſcends almoſt to the Bottom of the Bowl. This Tunnel is open at both Ends *B C*. *B* dips into the Liquor *E*, which is at the Bottom of the Bowl.

The Space of the Bottle of Glaſs is fill'd with Air, which has no Communication with the exterior Air.

Fig. 3.

When the Air contain'd in this Space is rarified by the exterior Air which touches the Bottle, it preſſes at the ſame Time the Liquor *E*, and obliges it to riſe by *B* in the Tunnel *B C*. On the contrary, when it condenſes by the exterior Cold, by not preſſing the Liquor *E*, it permits that which is in the Tunnel to fall.

The Readineſs with which the Air condenſes or rarifies by Cold and Heat, makes the Effects of this Thermometer much more ſudden than thoſe of any other ſort: Beſides, the Effects of this is much greater, the Air being capable of a greater Rarefaction, or of a greater Condenſation, than any other Liquor.

The Cauſe *of the* Variation *of the* Barometer, *&c. by Mr.* J. T. Deſaguliers. n. 351. p. 570.

V. *Remarks on the* Second *Paper in the* Hiſtory *of the* Royal Academy *of* Sciences, *for the Year* 1711, *concerning the* Cauſe *of the* Variation *of the* Barometer: *Shewing that the Way of accounting for it in that Paper is inſufficient, and that the Experiment made uſe of to prove what is there aſſerted, does no Way prove it.*

The Paper is as follows.] " It appears by the Barometer, that when it " rains, or a little before the Rain, the Air commonly becomes lighter.

" That

" That it muſt rain when the Air becomes lighter is eaſy to imagine;
" for the imperceivable Particles of Water, that ſwim about in the
" Air in prodigious Quantity, not being ſufficiently ſuſtain'd when the
" Air has loſt a certain Degree of its Weight, begin to fall, and ſeveral
" of them joining together in the Fall make Drops of Rain. So when
" about half of the Air is drawn out of the Recipient of the Air-Pump,
" (and conſequently the remaining Air is as weak again as at firſt) ſome-
" thing like a ſmall Rain falls. But why ſhould the Air become lighter?
" One might imagine that in the Place where it rains, it may have loſt
" ſome of its Weight and Bulk, by Means of the Winds carrying away
" ſome Part of it: But Monſieur *Leibnitz*, in a Letter to the Abbot
" *Bignon*, gives a more ingenious and more new Reaſon for it.

" He pretends that a Body, which is in a Liquid, weighs with that
" Liquid, and makes up Part of its whole Weight, ſo long as it is ſu-
" ſtained in it; but if it ceaſes to be ſuſtained, and conſequently falls,
" its Weight no longer makes a Part of the Weight of the Liquid, which
" thereby comes to weigh leſs. This may naturally be applied to the
" above-mentioned Particles of Water; they encreaſe the Weight of
" the Air when it ſuſtains them, which is diminiſhed when it lets them
" falls: And as it may often happen that the Particles of Water that
" are higheſt, fall a conſiderable Time before they join with thoſe that
" are low, the Gravity of the Air diminiſhes before it rains, and the
" Barometer ſhews it.

" This new Principle of Monſieur *Leibnitz* is ſurprizing. For muſt
" not a ſtrange Body, whether ſuſtained in a Liquid or not, always
" weigh? Can it gravitate upon any other Bottom than that which
" ſuſtains the whole Liquor? Does that Bottom ceaſe to carry a
" ſtrange Body, becauſe it falls? And is not that Body all the while it
" is falling, part of the ſaid Liquid as to the Weight? At that rate, whilſt
" a Chymical Precipitation is made, the whole Matter ought to weigh
" leſs, which has never been obſerved, and ſcarce appears credible.

" Notwithſtanding theſe Objections the Principle holds good, when
" more cloſely examin'd. What ſuſtains a heavy Body is preſs'd by it.
" A Table, for example, which ſuſtains a Pound Weight of Iron, is preſs'd
" by it, and is ſo only becauſe it ſuſtains the whole Action and Effect of
" the Cauſe of Gravity, (whatever it be) to puſh that Lump of Iron lower.
" If the Table ſhould yield to the Action of that Cauſe of the Weight
" (or Gravity) it would not be preſs'd, and therefore would carry no-
" thing. After the ſame Manner, the Bottom of a Veſſel, which contains
" a Liquid, oppoſes itſelf to all the Action of the Cauſe of Gravity againſt
" the ſaid Liquid: If a ſtrange Body ſwims in it, the Bottom oppoſes itſelf
" alſo to the ſaid Action againſt that Body, which, being in *Æquilibrio* with
" the Liquid, is in that reſpect really a Part of it. Thus the Bottom is
" preſt both by the Liquid and the ſtrange Body, and ſuſtains them both.
" But if the Body falls, it yields to the Action of Gravity, and conſe-
" quently the Bottom does no longer ſuſtain it; neither will it ſuſtain

" it, till the ſaid Body is come down to the Bottom. Therefore du-
" ring the whole Time of the Fall, the Bottom is eaſed of the Weight
" of that Body, which is no longer ſuſtained by any Thing, but puſh'd
" down by the Cauſe of Gravity, to which nothing hinders it from
" yielding.

" Monſieur *Leibnitz* to confirm his Notion, propoſed an Experi-
" ment. He ſays, that two Bodies muſt be tied to the two Ends of
" a Thread, the one heavier, and the other lighter than Water, yet
" ſuch as both together may ſwim in Water: Put them into a Tube
" full of Water, the Tube being tied to one End of the Beam of a
" Ballance whoſe other End has a counterpoiſing Weight: Then if we
" cut the Thread which ties the Bodies together (that are of unequal
" Weight) ſo that the heavieſt may preſently deſcend, he ſays, that
" in ſuch a Caſe the Tube would be no longer in *Æquilibrio*, but its
" counterpoiſing Weight would preponderate, becauſe the Bottom of
" the Tube would be leſs preſs'd. It is plain, that the Tube muſt be
" ſufficiently long, that the falling Body may not reach the Bottom
" before the Tube has Time to riſe. In Chymical Precipitations, the
" Veſſels are either too ſhort, or what is precipitated falls ſometimes
" too faſt and ſometimes too ſlow; for then the little Bodies are always
" (as to Senſe) *in Æquilibrio* with the Liquor that contains them.

" Monſieur *Ramazzini*, the famous Profeſſor at *Padua*, to whom
" Monſieur *Leibnitz* had propoſed his Experiment, has made it with
" Succeſs, after ſome fruitleſs Trials. Monſieur *Reaumur* (to whom
" the Academy had recommended it) has alſo made it with Succeſs.

Fig. 4. *Remarks upon Monſieur* Leibnitz's *New Principle.*] Let *AB* be the Bottom of a Veſſel full of any Fluid, whoſe Top is either wider than the Bottom as *GH*, narrower as *EF*, or equal to it as *CD*. The Preſſure of the Fluid upon the Baſe *AB* will be equal to the Weight of *CB*, or of a Cylinder or Priſm of the ſame Fluid, made up of the Area of the Baſe multiplied into the perpendicular Height above it.

If the Fluid be equally denſe every way as Water, or of a Denſity uniformly diminiſh'd as you go upwards, this Propoſition (called by Mr. *Boyle* the Hydroſtatical Paradox) will hold good. This is demonſtrated by all Hydroſtatical Writers.

Fig. 5. Let *EF* repreſent Part of the Surface of the Earth, and *GEFH* a Pillar of the Atmoſphere, whoſe Height is *GE* the whole Height of the Air. Let us imagine the Vapours riſing out of the Earth to form themſelves into two Clouds *A* and *B*, and to ſettle in that Place where the Air is of the ſame ſpecifick Gravity with themſelves. It is evident that they will cauſe the Air to riſe ſo much higher as their Bulk amounts to, and will therefore make the Surface which was at *GH* to riſe up to *IK*, ſo that the Bottom *EF* which was preſs'd by a Pillar of Air as *GEFH*, is now preſs'd by an higher Pillar as *IEFK*. Now if the Clouds *A*, *B*, by any Cauſe ſoever, change their Place, ſo as to come downwards, (for *Example* to *C*, *D*) the

Height of the Pillar *I E F K* will remain the ſame as it was, and therefore the Bottom *E F* will be preſs'd as before by the foregoing Propoſition.

Corol. 1.] If the Clouds *A B* deſcend, and in their Deſcent keep the ſame Bulk as they had before, the Surface *I K* will remain the ſame, and therefore *E F* will be preſs'd as before.

Corol. 2.] Whether a Body be ſpecifically lighter or ſpecifically heavier than a Fluid; ſo long as it is detain'd in it, it will add to the Fluid as much Weight as the Weight of an equal Bulk of that Fluid: Wherefore a Body does not loſe all that Weight which it added to the whole Weight of the Fluid, when it ceaſes to be ſuſtain'd in the ſaid Fluid; contrary to Monſieur *Leibnitz*'s Principle.

Schol.] If a Cloud (by any Cauſe whatſoever) becomes ſpecifically heavier than that Part of the Air in which it ſwims, the Exceſs of its Gravity above an equal Bulk of Air will make it deſcend, and accelerate its Motion downwards; and then indeed it will loſe of its Weight by the Reſiſtance of the *Medium*, till it comes to an uniform (or ſenſibly uniform) Motion: but all the Weight that it will loſe will only be the Exceſs of its Gravity above that of the Air; for with the reſt of its Weight it will ſtill make up Part of the Weight of the Air.

Experiment 1.] Having with a Weight in the Scale *C* of the Balance *A B* counterpois'd the long Glaſs of Water *E I*, with a Horſe-Hair I let down the leaden Weight *W* into the Water, which from *F G* aroſe up to *E H*; and therefore the Water became heavier by the Weight of a Bulk of Water equal to the Lead. Having with another Weight in *C* made up the Counterpoiſe to the whole, with fine Sciſſars I cut the Thread of the Plummet; and all the while the Plummet was falling, the Water deſcended rather than roſe; and when the Lead was at the Bottom the Water overpois'd, becauſe it had then added to it all the Exceſs of Weight of the Lead above an equal Bulk of Water, which by Experiment is about $\frac{1}{11}$ of its Weight. Had Meſſieurs *Reaumur* and *Ramazzini* tried the Experiment thus, the Succeſs had been the ſame; but M. *Ramazzini* (as I underſtood from a Gentleman who was preſent) tried it in the following Manner, as I have ſince done. Fig. 6.

Experiment 2.] Making uſe of the abovementioned Machine, after I had balanc'd the Water and Lead in it, I fix'd to the End of the Beam *B* the Thread of the Plummet, which in the former Experiment I held in my Hand. This added to the Weight hanging at *B*, and oblig'd me to put into the other Scale a Weight equal to $\frac{1}{11}$ of the Lead, to recover the *Æquilibrium*. Then cutting the Thread or Hair, the Scale with the Weights overpois'd whilſt the Lead was falling; but the *Æquilibrium* was reſtor'd when it came to the Bottom. So that the Lead even then muſt have loſt only its Exceſs of Weight above Water. Fig. 7.

Experiment 3.] I tried the Way propoſed by Monſieur *Leibnitz* in the following Manner.

Fig. 8. I took a Cork *C* weighing an Ounce, and ſomething more than four times lighter than an equal Bulk of Water, and a Ball of Antimony *W* about four times ſpecifically heavier than Water, and of four Ounces Weight. The Cork laid upon the Water in the Veſſel *E A B D* rais'd the Water from *S S* to *G G*, and added an Ounce to the Weight of the whole Water: then ſuſpending the Ball of Antimony by a String, and letting it hang in the Water at *N*, it rais'd the Water from *G G* to *H H*, and ſo added another Ounce to the Weight of the Water. Then tying the Antimony to the Cork, the Cork had added to it three

Fig. 9. Quarters of the Weight of the Antimony which the Hand before had ſuſtain'd, and made it ſink ſo as to be almoſt cover'd, and raiſed the Water to *i k*, adding three Ounces to its Weight. Hanging this Veſſel of Water upon the Balance, and a Counterpoiſe at the other End, upon cutting the String the Veſſel of Water was rais'd up, and the *Æquilibrium* was not reſtor'd till the Antimony came to the Bottom.

By obſerving that as the Cork (being freed from the Weight of the Antimony) aroſe, and that during the Fall of the Body, the Water ſunk to *h h*, it appears that this is, in Effect, the ſame Experiment as the former, and concludes no more. As to the real Cauſe of the Variation of the Barometer, namely, the Accumulation of the Air by Winds over the Place where the Barometer riſes; and Part of the Air

Vid. Supra. V. II. p. 20. being blown away where the Mercury in the Barometer ſinks, ſee Dr. *Halley*'s Account of it in the *Phil. Tranſact.* Numb. 181.

Poſtſcript.] In making the firſt Experiment before the R. Society, of a Piece of Lead ſuſpended by a Thread, whilſt it was wholly cover'd with Water in the large Tube in which it hung (whoſe Length was four Feet) it was obſervable, not only that the End of the Balance (to which the Tube of Water with the Lead in it was fixed) did not riſe when the Thread was cut, (to let the Lead fall from the Top to the Bottom of the Tube) as it muſt have done according to M. *Leibnitz*'s Principle; but that the ſaid End of the Balance began to deſcend from the Time that the Lead began to fall. Therefore to be ſure that it was not the Plummet's rubbing againſt the Sides of the Tube in its Fall, which cauſed that *Phænomenon*, I hung to the Balance a long Glaſs of three Inches Diameter inſtead of the Tube, and making the Experiment as before, it ſucceeded in the ſame manner: the End of the Balance, which carried the Veſſel of Water ſunk as ſoon as the Thread of the Plummet was cut; tho' this Glaſs was not above half ſo long as the Tube.

When by holding of the String I drew the Lead upwards and downwards in the Water, there was no ſenſible Alteration of the *Æquilibrium*. Neither was it alter'd by cutting the String of a Stone-Plummet, becauſe of the Shortneſs of the Glaſs, and the little Exceſs of ſpecific Gravity in the Stone: for the greater the Difference is

betwixt

betwixt the Body made uſe of in this Experiment and Water, as well as the bigger the Body itſelf is, the better the Experiment will ſucceed.

Hence it appears, that when a Body, ſpecifically heavier than a Fluid, is (by what Cauſe ſoever) detain'd in any Place of the ſaid Fluid, it adds as much to the Weight of the whole Fluid as an equal Bulk of the ſaid Fluid amounts to: And when the ſaid Body, by the Action of its Exceſs of ſpecific Gravity above the Fluid, deſcends with an accelerated Motion; ſo long as that Motion is accelerated, the Reſiſtance of the Fluid (which is as the Square of the Velocity) takes off ſomething of the whole Weight of the Body; but as much as the Body loſes, ſo much the Water gains, over and above what was given it by its riſing on Account of the immers'd Body.

A Body therefore that falls in a Fluid is ſo far from making the Fluid lighter as it falls, that it makes it preſs more upon the Bottom that ſuſtains it, when it is falling, than when it was at reſt in the Fluid.

If the Veſſel of Water be long enough for the falling Body to come to an uniform Motion before it reaches the Bottom, the Force impreſs'd on the Water under the Body will make it preſs the Bottom, as much as if the Body were actually at Bottom, the Body in that Caſe loſing all its Exceſs of Gravity above that of the Water, and the Water gaining it.

Hence it follows, that a falling Cloud, when it comes to an uniform Motion, will not only add to the Weight of the Air as much as the Weight of an equal Bulk of Air; but even as much as its whole Weight amounts to, tho' it be ſpecifically heavier than the Air about it.

All the Diminution of Weight that can be allow'd in this Caſe is this. If we imagine the Air to have a ſmooth, regular Surface, as we have at firſt ſuppos'd, or if that be not allow'd, we may take any imaginary Surface of it above the Clouds) when a falling Cloud is diminiſh'd in Bulk, (as when it is chang'd into Rain) the Surface of the Air will ſubſide in Proportion to that Diminution, and therefore will weigh leſs, by ſo much as is the Weight of a Quantity of Air equal to the Bulk that Cloud has loſt: But when the Drops of Rain after Acceleration (occaſion'd by their Exceſs of Gravity above that of the Air) are come to an uniform Motion by the Reſiſtance of the Air, they reſtore to the Air the Weight that it had loſt. Now this uniform Motion being acquir'd in about two Seconds of Time, and the Diminution of Gravity in the Air being inſenſible, when compared to near three Inches of Mercury (for ſuch is the Variation of the Barometer with us) can no way be the Occaſion of thoſe ſo ſenſible Alterations in it, which happen ſome time before Rain or Fair Weather.

Add to this, that the whole Quantity of Rain that falls in England *and* France, *in the Space of one Year, ſcarce ever equals two Inches of* Mercury: *And in moſt Places between the* Tropicks, *the Rains fall, at certain Seaſons, in very great Quantities, and yet the* Barometer *ſhews there very little or no Alteration.*

Experiments made with the Barometer, *by Dr.* J. Scheuchzer. n. 344. p. 266.

VI. Experimenta hæc Barometrica pro variâ diverſi Aeris Elaſticitate exploranda, in variis *Helvetiæ* locis (occaſione Excurſionis Alpinæ, menſe Sept. 1714. ſucceptæ) facta fuere ope Tubi 32 digit. *Pariſin.* longi, 2 linn. diametro.

Columna *prima* notat Aerem in Tubo relictum. *Secunda* altitudinem Mercurii ſupra Argenti vivi ſuperficiem; *Tertia* ſpatia Aeris expanſi. *Quarta* notat deſcenſum Mercurii propter Aerem relictum.

D. 6. Septembr. *Tiguri*, Barometri totius altitudo hor. 8. ant. erat 26 digit. *Pariſin.* 4 linn. H. 9½ vero 26 digg. 4½ linn.

Col. I.	Col. II.		Col. III.		Col. IV.	
digg.	digg.	lin.	digg.	lin.	digg.	lin.
3	19	9 bis	12	6½ bis	6	7½
6	16	8	15	7½	9	8½
	16	7½	15	8	9	9
9						
12	11	11 bis	20	3 bis	14	5½
15	9	9 bis	22	6 bis	16	7½
18	7	5½ }	24	8½ }	18	11
	7	6 }	24	8 }	18	10½
21	5	3	27	0 bis	21	1½
24	3	3	28	11 bis	23	1½
27	1	6	30	7½ bis	24	10½
30	0	4	31	10½ bis	26	0

D. 11. Sept. in Paſcuo *Alpino* **Ennenſewen gen Averen** Montis Liberi, *Glaronenſis* ditionis, h. 1. pom. cœlo ſereno Altitudo totius Barometri 23. 10 bis.

Col. I.	Col. II.		Col. III.		Col. IV.	
digg.	digg.	lin.	digg.	lin.	digg.	lin.
3	18	7	13	6	5	3
6	15	7½	16	4	8	2½
9	13	3	18	7	10	7
12	11	1½	20	9	12	8½
15	9	0	22	9	14	10
18	6	11	25	0	16	11
21	4	11	26	10	18	11
24	3	0	28	10	20	10
27	1	4	30	5	22	6
30	0	2	31	8	23	8

D. 12.

D. 12 Sept. h. 7. ant. cœlo ſereno, **auff Scherf** jugo editiore Montis Liberi. Altitudo totius Barometri 21. 8.

Col. I.	Col. II.		Col. III.		Col. IV.	
digg.	digg.	lin.	digg.	lin.	digg.	lin.
3	17	6	14	6	4	2
6	14	7	17	3	7	1
9	12	6	19	6	9	2
12	10	5	21	6	11	3
15	8	5	23	6	13	3
18	6	5	25	3	15	3
21	4	7	27	1	17	1
24	2	9 $\frac{1}{2}$	29	0 $\frac{1}{2}$	18	10 $\frac{1}{2}$
27	1	4	30	6	20	4
30	0	2	31	8	21	6

D. 12. Sept. h. 9. ant. cœlo ſereno, **auff dem Blattenſtock** jugo editiore Montis Liberi. Altitudo totius Barom. 21. 6.

3	17	2 $\frac{1}{2}$	14	6	4	3 $\frac{1}{2}$
6	14	5	17	5	7	1
9	12	4	19	6	9	2
12	10	4 $\frac{1}{2}$	21	5	11	1 $\frac{1}{2}$
15	8	7	23	4 $\frac{1}{2}$	12	11
18	6	7	25	3	14	11
21	4	8	27	3	16	10
24	2	9	29	0	18	9
27	1	3	30	5	20	3
30	0	3	31	6	21	3

D. 14. Sept. h. 12. intra ipſam Venam Chalybis *Sarunetanam*, 300 incirca paſſus ab oſtio, cœlo foris ſereno. Barometri totius altitudo 24. 4. & 24. 3.

3	18	9	13	1	5	7
6	15	9	16	1	8	7
9	13	5	18	5	10	11
12	11	3	20	7	13	1
15	9	1	22	9	15	3
18	7	0	24	10	17	4
21	4	11	27	0	19	5
24	3	0	28	10	21	4
27	1	4	30	6	23	0
30	0	3	31	6	24	1

Extra hanc Venam metalllicam ſub dio eandem altitudinem obſervavi Mecurii in Barometro integro, item in 3 & 9 digg. Aeris in tubo relicti. Sed notandum eſt aerem in intimis fodinæ partibus, ubi experimenta feci, fuiſſe ob ignem præterito die accenſum (quo venam duriſſimam coquunt foſſores) rarefactum, & locum hypocauſti inſtar moderatè calefactum.

N. B.

N. B. *Multis experimentis coram R. Societate factis compertum est, Aeris compressi vires Elasticas esse ut pondera comprimentia directè. His Cl.* Scheuchzeri *observatis patet eandem in Aere rarefacto obtinere regulam quam proxime; Nam licet differentia aliqua reperiatur, tanta non est, ut ab inæqualite diametri Tubi non facile oriatur. Ut autem experimenta hæc rite fiant, oportebit Tubi capacitatem, immisso unciatim Mercurio, in æquales partes dividi, loco partium longitudine æqualium.*

VII. *Observations on the* Weather *in a Voyage to* China, 1709, *by Mr.* J. Cunningham. n. 292. p. 1639.

Weather.	Winds.	Needles Inclin. or Depref. of the N. or S. Po. under the Horizon.	Needles Variation E. or W.	Longitude East from St. *Jago.*	Latitude N. or S.	Philoſ. Barom Altitude.	Ther. Altit. below Extream Heat.	Day of the Mon.
Rainy and Cloudy.	Variable Breezes, and 10 Hours calm.	dif 8° 30 N		6° 16 E	1° 26 N		5 Div.	*Jan.* 31
Rainy and cloudy with Lightning.	N S by W S W by S and 16 Hours calm.			6 11 E	1 18 N		4	*Febr.* 1
Fair.	Variable Breezes and 11 Hours calm.			6 13 E	1 14 N		5	2
Fair with Rain at noon	Variable.			5 57 E	1 07 N		5	3
Fair and cloudy, Rain in the Forenoon.	Variable.			5 49 E	0 27 N		2	4
Rainy and cloudy.	Variable with 9 hours calm.			5 44 E	0 00		4	5
Fair and cloudy with ſome Rain.	Variable with 4 hours calm.			5 35 E	0 30 S		4	6
Fair and cloudy.	Small Gales from E by S to S E by S.	3 30 S		5 08 E	1 46 S		5	7
Fair and pleaſant.	Eaſy Gales from E by S to S E by E.			4 56 E	3 00 S		4½	8
Fair and pleaſant.	Eaſie at E S E, and S E by E.			4 19 E	4 29 S		5	9
Fair and pleaſant.	Eaſie at S E by E and S E.	10 00 S		3 54 E	5 57 S		5	10
Fair and pleaſant	Fine Gales S E by E.		20 17 E	3 05 E	7 10 S		6	11
Fair and pleaſant.	E S E fine.		2 20 E	2 22 E	8 46 S		6	12
Fair and pleaſant with one Shower.	E S S and E by S.		2 50 E	1 37 E	10 29 S		8	13
Fair and cloudy with ſome Squales.	E by S and E.		3 30 E	1 20 E	12 05 S		7	14
Fair with one Squale.	E by N to E S E.		4 12 E	1 10 E	13 44 S		7½	15
Fair and pleaſant.	E by S and E.	19 00 S	4 10 E	1 10 E	15 09 S		7½	16
Fair and pleaſant.	E.		4 52 E	1 14 E	16 32 S		8	17
Fair and cloudy with one Shower.	E.		5 14 E	1 19 E	18 01 S		8½	18
Fair with one Shower	E by S to E by N.	30 00 S	5 42 E	1 29 E	19 14 S		7½	19
Fair and cloudy with ſeveral Squales.	S E by E to E by N ſmall.		6 18 E	1 15 E	20 05 S		8	20
Fair with 2 Showers.	N N E to E by N eaſie.			1 35 E	21 16 S		7	21

Day

Day of the Mon.	Ther. Altit. below Extream Heat.	Philoſ. Barom Altit.	Latitude N. or S.	Longitude E. from St. *Jago*.	Needles Variation E. or W.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon		Winds.	Weather.
22	7		22 23 S	1 54 E	7 02 E		dif	N N E to E by N.	Fair with one Shower.
23	5		23 47 S	2 39 E				N N E to N N W.	Fair and pleaſant.
24	5		25 21 S	3 28 E				N N E to N E by E.	Fair and pleaſant.
25	6½		26 38 S	4 09 E	8 00 E	39 00 S		N E by N to N N E.	Fair and pleaſant.
26	6½		27 49 S	4 52 E				N E by E to N.	Fair and pleaſant.
27	8		29 16 S	6 07 E				N to N W.	Fair ſometimes cloudy
28	8		30 01 S	7 34 E				W N W to W S W.	Cloudy & ſqually with Rain and Lightning.
29	10½		31 26 S	10 20 E				W N W to N by E freſh.	Squally with much Rain & ſome Thunder
March 1.	12½	8	31 10 S	11 49 E				NW to W moderate.	Uncertain with Thunder and Rain.
2	13	10	31 16 S	13 57 E	4 50 E	42 00 S		W to N W moderate.	Fair and cloudy.
3	17½	14	31 13 S	16 04 E				W to S freſh.	Cloudy and ſqually.
4	23½	18	30 26 S	17 51 E				S by E to S E by E.	Squally and cloudy.
5	26	19½	30 58 S	17 17 E				E S E and E by S.	Fair and cloudy.
6	24	20	32 07 S	17 08 E	3 05 E			E by S to E by N moderate.	Fair and cloudy.
7	23	26	33 06 S	16 54 E				E by N to S E by E ſmall.	Fair and cloudy.
8	32	32	33 14 S	18 26 E	2 05 E			SE to SSW moderate.	Fair and cloudy.
9	33	38½	32 45 S	19 59 E				S to S S W blowing hard.	Cloſe and ſqually.
10	29	34	32 27 S	21 13 E				S by E & S moderate.	Gray and cloudy.
11	29	32½	32 01 S	22 32 E				S by E to S E by E.	Squally, cloſe and cloudy.
12	28½	33½	32 36 S	22 23 E				S S E to E by S.	Dry, cloſe & cloudy.
13	27	34	33 42 S	22 42 E				E by S to E by N eaſy.	Fair and cloſe.
14	26	31	34 08 S	23 23 E	1 15 E			Variable and ſmall.	Fair and cloſe.
15	26	30	34 19 S	25 26 E	0 57 E			N to NW by N eaſie.	Fair and ſerene.
16	24	30	34 46 S	27 45 E	0 20 E			N by W to N N E.	Fair and ſerene, ſometimes cloſe.
17	25	30	34 55 S	29 48 E	0 22 W			N by E to N N W a fine Gale.	Fair and ſerene.
18	25½	30	34 59 S	33 27 E	1 19 W	47 00 S		N to N N W.	Fair and ſerene, this Forenoon cloudy.
19	34	38	34 44 S	36 25 E				N N W to S W and S by W.	Thick and Squally, this Forenoon fair.
20	26	31½	34 22 S	37 45 E	6 25 W			S W to N W eaſie.	Fair and cloudy.
21	28	33	34 29 S	39 04 E				NW by N to W eaſie.	Fair and cloudy.
22	37	42	34 08 S	41 31 E				W to S S E fine.	Fair and ſometimes ſqually.
23	30	36	34 35 S	43 41 E	7 05 W			S to W S W fine.	Variable Weather.
24	26½	32	34 08 S	45 06 E	8 80 W			SSW to WSW ſmall.	Fair and pleaſant.
25	27	30½	33 58 S	47 02 E	8 52 W			S W by S to S E by S eaſie.	Variable.

Weather

Weather.	Winds.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon	Needles Variation E. or W.	Longitude E. from St. *Jago.*	Latitude N. or S.	Philoſ. Baro. Altit.	Ther. Altit. below Extream Heat.	Day of the Mon.
Fair and cloudy.	SE by S to S by W moderate.		9 43 W	48 32 E	33 35 S	26½	25½	26
Variable.	SW by S to S moderate.		10 39W	49 56 E	33 51 S	29	27	27
Fine moderate Weather.	SW by S to S by W ſmall.			50 36 E	34 03 S	30½	35½	28
Fair and pleaſant.	SE ſmall, ſometimes freſh.			50 36 E	34 03 S	34½	33	29
Fair and pleaſant.	SW to SE moſt Part calm.	48 00 S		50 36 E	34 03 S	31	30	30
Fair and pleaſant.	Variable Breezes and calm.			50 36 E	34 03 S	25	26	31
The ſame.	S to SE ſmall.			At the	Cape			*Apr.* 1
The ſame.	SE ſmall.			of				2
The ſame.	SE and SE by S moderate.			*Good-*	*Hope.*			3
The ſame.	SE and SSE ſmall and calm.							4
The ſame.	SE by S ſmall, at Night freſh.							5
The ſame.	SE ſmall.							6
The ſame.	Variable and calm.							7
The Forenoon foggy, Afternoon clear'd up.	Calm, at Night blowing freſh.					34	30½	8
Fair and hazy	SSE and S by E blowing hard.			Long t. from the				9
Fair and pleaſant.	SSE fine Gales.			Cape of *Good Hope*				10
Fair and gray.	SE by S to NE moderate.			00 43W	34 45 S	29	31	11
Fair and cloudy.	Variable and ſmall.		11 29W	00 25W	35 01 S	28	26	12
Squally.	SSE to SE by E moderate.			00 08W	35 30 S	42½	33	13
Variable.	SE to E by N.			00 36W	36 52 S	44½	34½	14
Fair and cloudy.	E to ENE ſmall.			00 13W	37 51 S	29	25½	15
Variable.	S by E to SW by S ſmall, ſometimes calm		12 40W	1 03 E	37 57 S	31½	27	16
Variable.	SSW to ESE.			2 38 E	37 41 S			17
Fair and cloſe.	E by S to ENE ſmall.			3 29 E	38 45 S	38	31	18
Fair and cloudy.	E by S to NE by N moderate.			4 50 E	39 53 S	34	26	19
Cloudy and overcaſt.	NE by E to E by S moderate.			5 58 E	40 42 S	39	31	20
Moderate Weather.	NE by E to NE by N eaſy.			7 49 E	41 06 S	34	32½	21
Variable.	WSW to SE freſh.			10 06 E	39 52 S	45½	40	22
Fair and cloudy.	SE to SSE ſmall.		19 06W	11 34 E	38 51 S	44	38	23
Fair and pleaſant.	SE to NNE ſmall			11 50 E	39 09 S	33½	32	24
Fair and cloudy.	Variable Gales.			14 37 E	39 14 S	41	39½	25

Day

Day of the Mon.	Ther. Altit. below Extream Heat.	Philoſ. Baro. Altit.	Latitude N. or S.	Longitude E. from the Cape of *Good-Hope*.	Needles Variation E. or W.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon	dif.	Winds.	Weather.
26	46	55	38 00 S	17 06 E				W by N to S W blowing hard.	Variable with Rain and Hail.
27	36	45	37 41 S	19 10 E		60 00 S	8	S W by S to W N W freſh.	Cloſe and cloudy.
28	31	37	37 45 S	21 35 E	21 23 W			W N W to N W by N moderate.	Fair ſomewhat cloudy
29	25	36	37 27 S	23 32 E				N W to S W eaſie.	Variable.
30	23	33	37 30 S	23 57 E	22 27 W			W S W to S E by S ſmall.	Cloſe Weather.
May 1.	33	42	37 58 S	25 24 E				N N E to E ſmall.	Cloſe and cloudy.
2	32	45	38 16 S	27 00 E	24 30 W			N E by E to N by E eaſie.	Cloſe.
3	32	40	38 47 S	29 40 E				N E by N to N N W freſh.	Cloſe and ſqually.
4	30	31½	38 50 S	33 20 E				N N W to N W freſh	Fair and cloudy.
5	37	37	38 43 S	36 20 E		60 00 S	7	N W to S W freſh.	Variable and ſqually.
6	38½	45½	38 35 S	39 54 E				N W to S W eaſie.	Variable and ſqually
7	38½	45½	38 17 S	42 07 E		69 00 S	8	W N W to S W moderate.	Fair Weather.
8	46½	53	37 49 S	45 51 E	24 20 W			W N W to S W by W freſh.	Variable.
9	35	40	38 48 S	49 19 E				W S W and W N W freſh.	Variable.
10	32	39	38 30 S	52 41 E	24 00 W	72 00 S	8	W by N to N W by W freſh.	Variable.
11	35	16	38 09 S	56 08 E				W N W and W freſh.	Moderate with ſome Rain.
12	32	42	37 25 S	58 16 E				W to S W eaſie.	The ſame.
13	33½	47½	37 25 S	59 11 E	20 48 W			S W to N N E ſmall.	Cloudy Weather.
14	34	45½	37 10 S	60 54 E	20 00 W	75 00 S	8	W N W to N W by N. ſmall.	Fair and pleaſant.
15	30	38½	37 13 S	63 29 E	19 00 W			W N W to S W fine Gales.	Variable.
16	34	41	36 53 S	65 04 E	18 43 W	70 00 S	6	S W to W N W eaſie.	Cloſe and hazy with Rain.
17	31½	36½	36 48 S	68 14 E	17 40 W			WNW to NW freſh.	Variable.
18	35	41	36 56 S	71 12 E		68 00 S	8	W N W and W by N fine.	Fair and cloudy.
19	35½	41	36 00 S	74 16 E				W N W and W freſh.	Moderate.
20	32	34	35 01 S	76 39 E				N W by W to W fine.	The ſame.
21	32½	37	34 07 S	78 32 E	14 28 W	68 00 S	8	W by S to N W by N	The ſame.
22	27	25½	33 07 S	81 05 E	14 00 W			N W by N and N W	The ſame.
23	28½	24½	32 53 S	83 38 E	13 30 W			N W by N to N E	Variable.
24	35	33	31 35 S	85 13 E				N by E to W by S	Thick and ſqually.
25	29½	30½	30 11 S	86 28 E		68 00 S	8	S W to W N W	Variable.
26	31	34½	29 27 S	87 06 E	10 04 W			SW by W & SW by S	Fair and pleaſant.

Weather.	Winds.	Needles Inclin. or Depression of the N. or S. Point under the Horizon	Needles Variation E. or W.	Longitude E. from the Cape of *Good-Hope.*	Latitude N. or S.	Philos. Baro. Altit.	Ther. Altit. below Extream Heat.	Day of the Mon.
The same.	S W to S E small.	dif.		87 59 E	28 01 S	35	31	27
Variable.	S E and S E by E.		8 58 W	89 24 E	25 55 S	33	30	28
Squally & Rainy with Thunder & Lightning	S E by E to S S E.			90 29 E	23 59 S	20	27	29
Variable.	S E and S E by E.	8 62 00 S	8 12 W	91 32 E	22 49 S	24	25	30
Fair and serene.	S E to S S E.		7 00 W	92 42 E	21 23 S	22	22	31
Fair and pleasant.	S E and S E by E.		6 35 W	93 20 E	19 54 S	19	19	*Jun.* 1
The same.	S E by E and E S E.			94 10 E	18 02 S	17	17	2
The same.	S E by E and E S E.		4 40 W	94 55 E	16 30 S	13	14	3
The same.	E by S to E by N.	7 53 00 S	4 50 W	95 15 E	15 02 S	10	12	4
The same.	E by N to E by S.		5 12 W	95 34 E	13 40 S	7	7½	5
The same.	E to N E by E.	4 52 00 S	5 20 W	95 42 E	13 01 S	3	5	6
The same.	E by N to E S E.		5 15 W	95 56 E	12 59 S	3	5	7
The same.	E by N to S E.		4 42 W	96 17 E	12 26 S	3	5	8
The same.	E S E to E N E.		4 26 W	96 28 E	11 43 S	1	5½	9
The same.	E by N and E.		3 52 W	96 34 E	11 10 S	1	5	10
The same.	E by N to E S E.		3 32 W	96 54 E	10 18 S	0	4	11
The same.	E by S to E S E.	6 46 00 S	3 26 W	97 37 E	8 45 S	1	5	12
The same.	E by S to N N E.		3 12 W	97 21 E	7 52 S	1	5½	13
The same.	E S E to N N E.			95 56 E	7 23 S	0	4½	14
The same.	S S E to S E.			95 16 E	6 45 S	0	5	15
The same.	S S E, S S W and calm.			Betwixt		0	4	16
The same.	S S W, S E and calm.			*Java Head.*		0	2½	17
The same.	S E and E by S.			and		0	2	18
The same.	E N E and S E.			*Batavia.*		0	2	19
The same.	N E by E to S S E.					0	1	20
The same.	N N E to S.	3 40 00 S		Longit. from *Batavia.*		0	1	21
The same.	N to S S E.			00 05 W		0	1½	22
The same.	N W by W and S W.			00 47 E	5 27 S	0	4½	23
Cloudy with some Rain.	S by W and S E by E.			1 48 E	5 24 S	0	2	24
Squally with Thunder Lightning and Rain.	E S E to N by E.			1 55 E	5 51 S	0	3	25
Cloudy with Rain.	E S E to N E by E.	4 38 00 S		1 51 E	6 12 S	2½	6½	26
The same.	Calm.			1 59 E	6 16 S	0	5	27
Variable.	E by N to E S E small.			2 02 E	6 29 S	0	5	28
Fair.	E S E and S E small.			2 18 E	6 21 S	0	5	29
Uncertain.	Variable Breezes.			2 33 E	6 29 S	0	5	30
Fair with some Rain.	E by S to N E by E.			2 43 E	6 44 S	0	4	*July* 1
Fair with some Rain.	N E by E to S E by E.			2 55 E	6 39 S	0	4½	2
Fair and serene.	N E by E to S E by E.			3 34 E	6 35 S	0	3½	3
The same.	N E to S S E.			3 49 E	6 30 S	0	3½	4
The same.	N E by N to S E.	8 45 00 S		3 49 E	6 35 S	0	5	5

Day

Day of the Mon.	Ther. Altit. below Extream Heat.	Philoſ. Barom Altit.	Latitude N. or S.	Longitude E. from *Batavia.*	Needles Variation E. or W.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon		Winds.	Weather.
6	8	2	6 12 S	4 07 E			dif	S E ſmall.	The ſame.
7	6	0	6 21 S	4 28 E				S E by S to E.	The ſame.
8	6	0	6 22 S	4 43 E				S E by E to E N E.	The ſame.
9	6	1	6 28 S	5 13 E				E by S to E by N.	The ſame.
10	8½	3	6 50 S	5 37 E	1 25 W	41 10 S	2	S E by E to E by N.	The ſame.
11	6	0	6 44 S	5 47 E				E N E to S S E.	The ſame, with ſome Rain.
12	5	½	6 23 S	6 05 E				E by N to S E.	Fair and ſerene.
13	5	0	6 05 S	6 17 E				S E to E by S.	The ſame.
14	6	2	5 10 S	6 54 E				S E to E S E.	The ſame, with ſome Rain.
15	4	0	4 20 S	7 09 E				S E by S to E S E.	Fair and cloudy.
16	5	0	4 08 S	7 27 E				S E by E to N E by E.	Fair and ſerene.
17	5	0	4 00 S	7 30 E	At the *Banjar*	Bar of on *Borneo*		E to S E and calm.	Fair and cloudy.
18	8	4	4 00 S	7 30 E				E to S E by S ſmall.	Cloſe and cloudy with Rain.
19	7½	1	4 00 S	7 30 E				S E freſh.	Cloſe and clearing up.
20	6	0	4 15 S	7 06 E		40 00 S	0	S S E to S E.	Fair and ſerene.
21	5	0	4 51 S	5 08 E				S E by S and S E.	Fair and cloudy.
22	2½	0	4 59 S	3 12 E				S E by E to E by S.	The ſame.
23	4	0	4 45 S	1 25 E				S by E to E by S.	Cloſe with ſome Rain.
24	7	4	4 09 S	0 17 E				Variable.	Squally with Thunder
25	5	0	4 01 S	0 13 E		35 00 S	6	S to E by S.	Fair and cloſe with Lightning.
26	1½	0	3 32 S					E by S to S E by S.	Fair and ſerene.
27	3	0	In the	Streights				E N E to S by E.	Variable.
28	5	0	of	*Banca.*				S E by S to S.	Fair and ſerene.
29	4½	0	1 59 S					S E by E to S.	The ſame.
30	4	0	0 31 S	Longit.	1 50 W			S E to N N E.	The ſame.
31	4	0	1 25 N	from *Pulo*	*Condore.*	31 00 S	5	S S E to S E by S.	The ſame.
Aug. 1.	2½	0	3 19 N	1 36 W				S S E to S by W.	Fair and cloſe.
2	1	0	5 07 N	0 52 W				S by W to S E.	Variable with Thunder and Lightning.
3	1	0	6 04 N	0 25 W				Variable.	Fair and cloſe.
4	1	0	7 47 N	0 08 E				S S W to S W by S.	Fair and pleaſant.
5	3½	0	9 16 N	1 25 E				W to S W.	Fair, cloſe and hazy.
6	2	0	10 14 N	3 07 E				S W by W to W.	Fair and hazy.
7	1	0	12 04 N	4 33 E		5 30 S	12	S W by W to S W by S.	Fair and ſerene.
8	1	0	24 05 N	5 58 E		4 00 S	13	S W and S W by W.	The ſame.
9	1½	0	16 15 N	7 02 E				W by S to S W by S.	Fair and cloudy.
10	2½	0	18 14 N	7 20 E				Variable.	Squally.
11	1½	0	19 49 N	7 12 E				W S W to W N W blowing hard.	Squally and much overcaſt.
12	½	0	21 17 N	7 02 E		2 30 S	1	W S W to S S W moderate.	Fair and cloſe with ſome Rain.

Weather.	Winds.	Needles Inclin. or Depreſ. of the N. or S. Po. under the Horizon.	Needles Variation E. or W.	Longitude E. from *Pulo Condore*.	Latitude N. or S.	Philo. Baro. Altitude.	Ther. Altit. below Extream Heat.	Day of the Mon.
Fair and ſerene	S S W to S E by S ſmall.	dif		7 36 E	21 58 N	above Extr.	1½ Heat.	13
Fair and pleaſant with one Shower.	S E to N N E.	2 6 00 N		7 47 E	22 15 N	0	1 below	14
Fair and pleaſant.	E by N to N E by E.			8 09 E	22 18 N	0	1	15
The ſame.	Variable and calm.		1 20 W	8 43 E	22 32 N	0	0	16
Fair, with ſome drizling Rain.	W S W to S W eaſy.			9 48 E	23 10 N	0	½	17
Fair and ſerene.	Variable and ſmall.			10 04 E	23 32 N	0	1½	18
The ſame.	N to N E by N freſh.			10 18 E	23 56 N	0	2½	19
Fair and hazy.	N by E to N E by N.			10 28 E	24 12 N	0	4	20
The ſame.	N E by E to N by E.	6 12 00 N		10 43 E	24 22 N	0	1	21
The ſame.	N E to N N E.			11 01 E	24 32 N	0	3	22
Fair and pleaſant.	N E by E to N N E eaſy.			11 15 E	24 47 N	0	4½	23
Variable.	E N E to N E by N freſh.			11 28 E	24 56 N	0	6	24
Fair and pleaſant.	E N E to N by E moderate.			11 38 E	25 09 N	0	5	25
The ſame.	N by E to N E by E.			12 08 E	25 09 N	0	6	26
The ſame.	E N E to N N E.			12 20 E	25 07 N	0	5	27
Variable.	E by N to N N E.			11 50 E	25 29 N	0	5	28
Variable.	N E by E to N.			12 2 E	25 37 N	0	4	29
Cloſe and ſqually.	N by E to N E by E freſh.			11 47 E	25 49 N	0	3½	30
Variable.	N E by N to E by N.			11 53 E	26 02 N	0	2	31
Fair and pleaſant.	N N E to N E by E.			11 56 E	26 05 N	0	2½	Sep. 1.
The ſame, with ſome Rain at Night.	N E ſmall.			At *Crocodile* Iſland				2
Fair and pleaſant.	N N E ſmall.							3
The ſame.	N by E to N E.							4
Fair and cloudy.	N E moderate.							5
The ſame, at Night much Rain.	N E freſh, at Night S W blowing hard.							6
Cloudy with ſome Rain.	N E freſh and moderate.							7
Fair and pleaſant, at Times over-caſt.	N E moderate.							8
Fair and hazy.	N E moderate.			12 38 E	25 44 N	0	3	9
The ſame.	N E by N to N E by E.			12 13 E	26 11 N	0	3½	10
The ſame.	N E to N N E.			12 47 E	26 11 N	0	5	11
Fair and pleaſant.	N E by N to E by S ſmall.			12 37 E	26 22 N	0	4½	12
Fair.	E N E to N E moderate.			12 40 E	26 26 N	0	8½	13
Fair and cloudy.	N N E to E N E.			12 59 E	26 37 N	0	6½	14

Day

Day of the Mon.	Ther. Altit. below Extream Heat.	Philoſ. Barom Altit.	Latitude N. or S.	Longitude E. from *Pulo Condore*.	Needles Variation E. or W.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon		Winds.	Weather.
15	5	0	27 05 N	13 11 E			dif	N E by E to E by N	Fair cloſe and cloudy.
16	7	0	26 55 N	14 01 E				E N E to N by W.	Fair and cloudy.
17	8	0	27 07 N	14 13 E				N to N E by E.	The ſame.
18	10	7½	27 26 N	14 13 E				N E to N by E.	Variable.
19	9	6½	27 42 N	14 02 E				N by E to N E by E.	Fair.
20	7½	4	27 46 N	14 25 E				N E by E to N by E freſh.	Fair and cloudy.
21	12	10	28 03 N	14 25 E				N E to N N E moderate.	Fair and pleaſant.
22	15	12½	27 49 N	15 31 E				N E by N to N by E.	Fair with ſome Rain.
23	17	14	27 51 N	15 01 E				N N E to N freſh.	Fair and cloudy.
24	14	13	27 53 N	16 26 E				N by W to N by E ſmall.	Fair and much overcaſt.
25	14	12	28 10 N	15 36 E				N by E to N E by N.	Fair and cloſe.
26	13½	13	28 47 N	15 04 E				N by E to E by N.	Variable.
27	14	13	29 06 N	14 49 E		17 30 N	5	N N E to N E by E.	Fair and pleaſant.
28	15½	17	28 55 N	15 09 E				N N E to N E.	Fair and cloudy.
29	15	13	29 02 N	15 09 E	1 00 E			N E by N.	Fair ſometimes cloſe.
30	15	17	29 43 N	15 19 E				Variable from S S E to N W.	Fair pleaſant and cloudy.
Oct. 1.			29 56 N	14 55 E				W N W to N E by E.	Fair and cloſe.
2			29 56 N	14 55 E				N N W and N ſmall.	Thick and foggy with Rain.
3								N N W to N W ſmall.	Variable, Forenoon ſerene.
4								N to N E moderate.	Variable.
5								N N W to N W blowing freſh.	Fair and cloudy.
6								Forenoon calm, Afternoon S E freſh.	Fair and ſerene.
7								N N E to N E.	Cloudy with Rain.
8								N. to N N W.	Cloudy and overcaſt.
9								N by W to N E.	Cloudy hazy & Rain.
10	20	20	29 56 N	14 55 E				N E to S E moderate	Cloudy and fair
11	12	16	30 29 N	14 20 E				S E to S W ſmall.	Fair and ſerene.
12	17	15	30 25 N	14 20 E	At	*Chuſan*.		S W ſmall.	The ſame.
13	25	32						N N E to N E.	Fair and cloudy.
14	24	30	30 25 N	14 20 E	00 56 E	21 00 N		N E moderate.	Fair and cloudy.
15								N ſmall.	Fair and cloudy.
16	25	29						N E to E moderate.	Cloudy with ſome Rain.
17	16	14						S E ſmall.	Thick and hazy with Rain.
18	15	13						S E moderate.	Thick and hazy with much Rain.

Weather

Weather.	Winds.	Needles Inclin. or Depreſ. of the N. or S. Po. under the Horizon.	Needles Variation E. or W.	Longitude from *Pulo Condore*.	Latitude N. or S.	Philoſ. Barom Altitude.	Ther. Altit. below Extream Heat.	Day of the Mon.
Fair and cloudy.	NE ſmall.	dif				31	23½	19
The ſame.	NNE to ENE.					30	24	20
Cloudy with ſome Rain.	NNE to SE.					29	24	21
Fair and cloudy.	N to NW freſh.					30	25	22
Fair and pleaſant.	N by W to WNW ſmall.					30	26	23
The ſame.	S and SSE ſmall.					32	27¼	24
The ſame.	SE moderate.					28	24	25
The ſame.	SE to S by E moderate					26	22½	26
Cloudy with ſome Rain.	NW to N by W moderate.					27	20	27
Thick and hazy with Rain.	NW ſmall, ſometimes freſh.					45	36½	28
The ſame.	NW to N moderate.					58	45	29
Fair and cloudy.	NNW to N by E ſmall.					59	46	30
The ſame.	NW ſmall.					65	47	31

Note 1. That the Altitude of the Spirits in the Thermometer and Philoſophical Barometer was commonly taken at Noon.

Note 2. That the Account of the Winds and Weather at Sea, is from Noon to Noon.

Note 3. That the middle Inclination of the Dipping-Needle is ſet down with the Difference alſo which was made, as either Side of the Compaſs was turn'd Eaſt or Weſt: Which Difference at firſt was not taken Notice of. From whence this Difference ſhould ariſe, I cannot determine, the Compaſs ſeeming to be juſtly pois'd and equally divided.

For the few Chaſmata in the Columns of the Thermometer and Barometer, there needs no other Apology, than that I was not on Board to take an Account of them my ſelf.

A Regiſter of the Weather, &c. at Chuſan *in* China, 1700. *by Mr.* J. Cunningham. n. 292. p. 1648.

VIII. *Note* 1. The Iſland *Chuſan* is in 30° 25′. N. Latitude upon the Coaſt of *China*.

Note 2. That the following Obſervations were of a portable Barometer from *England*; which by a Barometer ſet up here were always $\frac{6}{10}$ of an Inch lower.

Note 3. That the Barometer ſtood about 18 Feet above the *Superficies* of the Sea at high Water.

November 1700.

1. Grey cloudy Weather, very cold and moderate Gales from N W to N.

2. Grey cloudy Weather with moderate Gales from N W to N, and very cold.

3. Grey cloudy Weather, very cold and ſmall Gales from N by W and N N W. At Night little Wind and more ſerene.

4. Grey cloudy Weather, very cold and moderate Gales at N N W and N by W.

5. Fair and ſerene Weather with ſmall Gales from N N W to N. The Air temperate.

6. Fair and pleaſant Weather, with ſmall Gales at N W and N N W.

7. Fair and pleaſant Weather, ſomewhat hazy, and ſmall Gales at N N W. At Night calm.

8. Fair and pleaſant Weather, with ſmall Gales at N. At Night little Wind.

9. Fair and ſerene Weather, with ſmall Gales at N. At Night calm.

10. Very ſerene and warm Weather, with ſmall Gales at N by W. In the Night calm.

11. Dry and ſerene Weather, with ſmall Gales from S E. At Night calm.

12. Dry and ſerene Weather, with ſmall Northerly Breezes. At Night calm.

13. The Morning foggy, all Day ſerene with ſmall Breezes at N N W.

14. The Morning grey and cloudy, toward Noon thick hazy Weather with drizling Rain till 8 at Night. All Day freſh Gales from W by S to N W. At Night leſs Wind and fair.

15. Grey cloudy Weather with moderate Gales from N W to N.

16. Fair and pleaſant Weather with ſmall Gales from N to N by E.

17. Dry and ſerene Weather with ſmall Gales at N and N N W.

18. Grey cloudy Weather, with moderate Gales from N W. In the Night cold.

19. Dry Weather ſomewhat cloudy, with ſmall Gales from N W to N. Cold at Night.

20. Dry and pleaſant Weather, with ſmall Gales at N N W.

21. Fair and pleaſant Weather, with ſmall Gales from W by S to N W.

22. Fair and pleaſant Weather, ſomewhat hazy with Gales at S E.

23. Fair and pleaſant Weather, the Afternoon overcaſt, with moderate Gales at N W to N.

24. Dry Weather, ſomewhat cloudy, with moderate Gales from N W W to N.

25. Fair and pleaſant Weather, with ſmall Gales from N by W. At Night calm and cold.

26. Fair and pleaſant Weather, with ſmall Breezes at N W for the moſt part calm. ☿ Altitude $30\frac{8}{10}$.

27. Grey cloudy Morning, with ſmall Gales at W N W. ☿ Altitude $30\frac{6}{10}$. In the Afternoon fair and pleaſant with ſmall Southerly Breezes. At Night calm.

28. Fair and pleaſant Weather, with ſmall Gales at N W. ☿ $30\frac{6}{10}$. The Afternoon ſmall Breezes at S W. At Night calm, and the Breezes veering to N, the Air temperate. ☿ $30\frac{4}{10}$.

29. Fair and ſerene Weather, with Calms. ☿ $30\frac{5}{10}$. In the Afternoon ſmall Gales at S E. At Night grey cloudy Weather, the Gale veering to N. ☿ $30\frac{6}{10}$.

30. A grey cloudy Morning, with moderate Gales at N W and W N W. ☿ $30\frac{6}{10}$. All Day more ſerene. In the Evening overcaſt, and ſome Rain at 9 of the Night.

December 1700.

1. Grey cloudy Weather all Day and Night with freſh Gales from N to N E. ☿ $30\frac{9}{10}$ falling to $30\frac{8}{10}$.

3. In the Morning fair and ſerene. ☿ $30\frac{5}{10}$. Since overcaſt and grey cloudy Weather, with moderate Gales at N N E and N. In the Evening ſome Drops of Rain, and ſometimes blowing freſh in the Night, and very cold.

4. Grey cloudy Weather, with moderate Gales at N to N W. ☿ $30\frac{12}{10}$, at Night falling to $30\frac{11}{10}$, then almoſt calm.

5. A grey cloudy Morning, towards Noon more ſerene. ☿ $30\frac{11}{10}$. Freſh Gales at N E. In the Evening overcaſt, with ſome Drops of Rain. Little Wind all Night.

6. A grey Morning ſomewhat cloudy, and a ſmall Breeze at N N E. ☿ $30\frac{9}{10}$. In the Afternoon overcaſt, with the Wind at S, and ſmall Drops of Rain. The ☿ falling to $30\frac{8}{10}$. Some Rain in the Night.

7. Cloſe thick Weather with drizling Rains all Day and Night, and ſmall Winds at N N E and N. ☿ $30\frac{7}{10}$.

8. A grey cloudy Morning with ſome drizling Rain, and moderate Gales at N and N by W. ☿ riſing above $30\frac{7}{10}$. All Day and Night overcaſt; the ☿ as before.

9. A grey cloudy ſharp Morning, and ſmall Winds at N N W ☿ $30\frac{6}{10}$. Cloudy all Day, and towards Evening cloſe Weather and calm. ☿ $30\frac{5}{10}$.

10. Dry Weather ſomewhat grey and cloudy with ſmall Breezes at N N W. ☿ $30\frac{4}{10}$. All Day overcaſt with variable Breezes intermix'd with Calms. ☿ as before.

11. Fair

11. Fair and pleaſant in the Morning, ſince overcaſt with variable Breezes, the ☿ as before.

12. Grey cloudy Weather, in the Forenoon ſmall Gale at S E. ☿ 30 $\frac{4}{\frac{1}{2}0}$. In the Afternoon the Gale freſhning at N W. ☿ 30 $\frac{5}{\frac{1}{2}0}$. With ſome Rain all Night.

13. Grey cloudy Weather, with moderate Gales from N W to N. ☿ 30 $\frac{4}{\frac{1}{2}0}$. Cold at Night.

14. A ſharp Morning and fair pleaſant Weather, with ſmall Gales at N N W and N. ☿ 30 $\frac{6}{\frac{1}{2}0}$. At Night calm. ☿ 30 $\frac{5}{\frac{1}{2}0}$.

15. Fair and pleaſant Weather, with moderate Gales at S E ☿ 30 $\frac{4}{\frac{1}{2}0}$ falling to 30 $\frac{3}{\frac{1}{2}0}$.

16. The Morning ſomewhat cloudy, with ſmall Gales at S E. ☿ 30 $\frac{3}{\frac{1}{2}0}$. At Noon veer'd to N W, and the Sky overcaſt; at Night ſome Rain, much Wind and Cold.

17. A ſharp Morning and grey cloudy Weather, with moderate Gales from N W to N N W. ☿ 30 $\frac{7}{\frac{1}{2}0}$. All Day overcaſt, at Night little Wind and much Rain.

18. Thick cloſe rainy Weather, all Day and Night with ſmall Gales at N W.

19. Grey cloudy Weather, with moderate Gales at N W to N. ☿ $\frac{6}{\frac{1}{2}0}$. Some Rain at Night and very cold.

20. Grey cloudy Weather, with moderate Gales at N N W. ☿ 30 $\frac{7}{\frac{1}{2}0}$. At Night little Wind.

21. Grey cloudy Weather and cold, with moderate Gales from N N W to N W. ☿ 30 $\frac{7}{\frac{1}{2}0}$. At Night drizling Rains. ☿ 30 $\frac{6}{\frac{1}{2}0}$.

22. In the Morning cloſe Weather, with drizling Rains and moderate Gales at N W and N N W. ☿ 30 $\frac{6}{\frac{1}{2}0}$. The Afternoon dry, grey and cloudy.

23. A grey cloudy Morning and calm, ☿ 30 $\frac{5}{\frac{1}{2}0}$, towards Noon more ſerene and a ſmall Breeze at E S E. In the Evening overcaſt with ſome Rain and freſh Gales, all Night at N N W.

24. Grey cloudy Weather, ſomewhat cloſe, with freſh Gales from N N W to N W by W.

25. Grey cloudy Weather, with moderate Gales at N W.

26. Cloſe Weather with drizling Rains, and ſmall Breezes at N E, for the moſt calm. In the Night the Gale freſhned at N. ☿ $\frac{6}{\frac{1}{2}0}$.

27. The Forenoon grey cloudy Weather, and ſmall Gales at N N E. ☿ 30 $\frac{7}{\frac{1}{2}0}$. The Afternoon and all Night cloſe Weather with drizling Rains, the Breeze veering to E N E.

28. Grey cloudy Weather with ſome drizling Rains, and ſmall northerly Gales. ☿ at 30 $\frac{7}{\frac{1}{2}0}$.

29. In the Morning ſomewhat fair, then overcaſt with drizling Rains and cloſe Weather all Day and Night, ſmall Gales from N N E to N E. ☿ 30 $\frac{6}{\frac{1}{2}0}$.

30. A grey cloudy Morning, with Gales at E N E. ☿ 30 $\frac{7}{20}$. All Day the foreſaid Weather.

31. In the Morning fair and pleaſant, with ſmall Gales at S E. ☿ 30 $\frac{5}{20}$. In the Forenoon overcaſt, ☿ falling to 30 $\frac{3}{20}$. The Afternoon and Night cloſe thick foggy Weather, with ſome drizling Rain and calm.

January, 1701.

1. Dry Weather, ſomewhat cloſe, with ſmall Gales at S E. ☿ 30 $\frac{1}{20}$. The Afternoon over-caſt and cloſe Weather, with ſmall Gales at E S E. ☿ falling to 29 $\frac{19}{20}$, and much Rain in the Night.

2. Cloſe Weather and drizling Rains, with moderate Gales at N N E. ☿ 30 $\frac{1}{20}$. At Night blowing freſh, ☿ riſing to 30 $\frac{3}{20}$.

3. Cloſe and cloudy Weather, with drizling Rain, and moderate Gales at N. ☿ 30 $\frac{5}{20}$.

4. A grey cloudy Morning, with moderate Gales at N E. ☿ 30 $\frac{1}{20}$. Afternoon cloſe and thick Weather, with drizling Rains. ☿ 30. Much Rain in the Night.

5. Thick cloſe rainy Weather, with moderate Gales at N E. ☿ 30 $\frac{3}{20}$. At Night fair and cold.

6. A grey cloudy Morning, with freſh Gales at N E. ☿ 30 $\frac{6}{20}$. At Noon 30 $\frac{7}{20}$. At Night 30 $\frac{6}{20}$, and ſome Rain.

7. Cloſe and cloudy Weather, in the Morning. ☿ 30 $\frac{5}{20}$. Towards Noon drizling Rains, and encreaſing in the Afternoon, with ſmall Winds at N E. ☿ 30 $\frac{4}{20}$.

8. Thick cloſe and cloudy Weather, with drizling Rains and ſmall Gales at N E. ☿ 30 $\frac{2}{20}$.

9. Cloſe and cloudy Weather, with drizling Rains and ſmall Gales at E S E. ☿ 30 $\frac{4}{20}$. At Night fair. ☿ 30 $\frac{6}{20}$.

10. A grey cloudy Morning with freſh Gales at N. ☿ 30 $\frac{7}{20}$. In the Evening and all Night rainy Weather.

11. A cloſe and cloudy Morning with drizling Rains and ſmall Gales at N. ☿ 30 $\frac{5}{20}$. All Day the aforeſaid Weather.

12. Thick cloſe rainy Weather all Day and Night, with moderate Gales at N N W. ☿ 30 $\frac{2}{20}$. Much Rain at Night.

13. Very thick cloſe rainy Weather, with freſh Gales at N W. ☿ 30. In the Night cold.

14. A ſharp cold Morning, with much Snow falling and cloſe Weather, with freſh Gales at N W. ☿ 30 $\frac{2}{20}$. Continu'd Snowing a little all Day and Night following. ☿ 30 $\frac{3}{20}$.

15. Fair Weather, freezing hard, with ſome Sun-ſhining and freſh Gales at N N W and N by W. ☿ 30 $\frac{5}{20}$.

16. Fair and ſerene Weather all Day and Night, freezing hard, with moderate Gales at N N W. ☿ 30 $\frac{7}{20}$. The Sun melting the Snow.

17. Fair and ſerene Weather, (the Sun diſſolving moſt of the Snow) with freſh Gales at N by W. ☿ 30 $\frac{2}{20}$. At Night ſomewhat cold, freezing hard.

18. Grey

18. Grey cloudy Weather, freezing hard, with moderate Gales at N by W. ☿ 30 $\frac{11}{20}$. At Night riſing to 30 $\frac{12}{20}$.

19. Grey cloudy Weather, with little Froſt, and moderate Gales at N N W. ☿ 30 $\frac{10}{20}$.

20. Grey cloudy Weather, ſomewhat cloſe, with moderate Gales at N N W. ☿ 30 $\frac{9}{20}$, freezing in the Morning, and inclining to thaw at Night.

21. In the Morning ſomewhat ſerene, the reſt of the Day overcaſt, with moderate Gales at N W, and ſome Thaw. ☿ 29 $\frac{9}{20}$.

22. Fair and ſerene Weather, with ſmall Gales at W N W. ☿ 30 $\frac{7}{20}$, thawing all Day with the Heat of the Sun, at Night cold, but not freezing. ☿ as before.

23. Grey and cloudy Weather, with ſmall Gales at S E, thawing a little ☿ 30 $\frac{5}{20}$. At Night much Rain and calm. ☿ 30 $\frac{4}{20}$.

24. A fair and ſerene Morning with ſmall Gales at N N W and N. ☿ 30 $\frac{4}{20}$. All Day overcaſt, and drizling Rains all Night.

25. Cloſe hazy Weather, with drizling Rain and no Wind. ☿ 30 $\frac{4}{20}$. At Night much Rain.

26. Very cloſe hazy Weather, with drizling Rains and ſmall Breezes at S E. ☿ 30 $\frac{2}{20}$. In the Afternoon falling to 29 $\frac{18}{20}$, at Night much Rain, the Wind veering to N N W. blowing ſometimes in Guſts.

27. Cloſe Weather, with drizling Rains and moderate Gales at N W. ☿ 30 $\frac{2}{20}$. In the Afternoon fair, and at Night freezing.

28. Grey cloudy Weather, freezing hard all Day, with moderate Gales from N W to N. ☿ 30 $\frac{4}{20}$. *This Day being New Moon, begun the* Chineſe *New Year.*

29. Fair and ſerene froſty Weather, with moderate Gales at N by W. ☿ 30 $\frac{6}{20}$.

30. The Morning fair and ſerene, all Day overcaſt with moderate Gales at N to N W. ☿ 30 $\frac{7}{20}$. Froſty Weather.

31. Fair and ſerene Weather, freezing hard, with moderate Gales at W N W. ☿ 30 $\frac{7}{20}$.

February.

1. Fair and pleaſant Weather, with ſmall Gales from W, veering to S S E, and at Night to N N W, but no Froſt. ☿ 30 $\frac{6}{20}$.

2. Fair and pleaſant Weather, in the Morning, little Wind, in the Forenoon fine Gales at N W. ☿ 30 $\frac{8}{20}$. At Night little Wind.

3. Dry Weather, ſomewhat over-caſt, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$. At Night little Wind.

4. Dry Weather, ſomewhat cloſe, with ſmall Gales at S E. ☿ 30 $\frac{6}{20}$.

5. Fair and cloudy Weather, with ſmall Gales at N W. ☿ 30 $\frac{4}{20}$.

6. The Morning cloſe and over-caſt, the Afternoon ſerene, with ſmall Gales at N W. ☿ 30 $\frac{5}{20}$.

7. Fair and cloudy Weather, with ſmall Gales at N N W. ☿ 30 $\frac{6}{10}$.

8. Fair Weather, ſomewhat cloudy, with variable Breezes round the Compaſs. ☿ 30 $\frac{6}{10}$.

9. Fair and pleaſant Weather, with ſmall Breezes at S E. ☿ 30 $\frac{7}{10}$. At Night little Wind from N N W.

10. Cloudy Weather, with moderate Gales at N by W, in the Afternoon and all Night drizling Rains. ☿ 30 $\frac{4}{10}$.

11. Cloſe Weather, with drizling Rains and ſmall Gales at N by W. ☿ 30 $\frac{1}{10}$. All Night much Rain.

12. Cloſe Weather, with ſome drizling Rains and ſmall Gales at N by W, and N N W. ☿ 30 $\frac{2}{10}$.

13. Fair and pleaſant Weather, with ſmall Gales from N to S S E. ☿ 30 $\frac{5}{10}$.

14. Cloſe and cloudy Weather, with drizling Rains, and ſmall Gales at N N W. ☿ 30 $\frac{1}{10}$. Afternoon and Night fair, pleaſant and calm, ☿ as before.

15. Fair and ſerene Weather, and no Wind. ☿ 30 $\frac{3}{10}$. The Afternoon overcaſt, with cloſe Weather, and moderate Gales at S E, and ſome Rain. ☿ 30.

16. Cloudy Weather and ſomewhat cloſe, with ſmall Gales at N N W. ☿ 29 $\frac{12}{10}$. In the Night freſher Gales.

17. Grey cloudy Weather with moderate Gales at N N E. ☿ 30 $\frac{3}{10}$.

18. Grey cloudy Weather, with moderate Gales at N. ☿ 30 $\frac{4}{10}$.

19. Grey cloudy Weather, with moderate Gales at N N W. ☿ 30 $\frac{4}{10}$.

20. Grey cloudy Weather, with ſmall Gales at N by W. ☿ 30 $\frac{6}{10}$. Very Cold with ſome Snow at Night.

21. Grey cloudy Weather, with ſmall Gales at N. ☿ 30 $\frac{2}{10}$. Some Snow this Morning, whitening the Tops of the Hills and lying all Day.

22. In the Morning ſome Sun-ſhining diſſolving the Snow; all Day grey cloudy Weather, and temperate with ſmall Gales at N N W. ☿ 30 $\frac{8}{10}$.

23. Dry Weather, ſomewhat cloudy, calm in the Morning, at Noon blowing freſh from N W till Night, then little Wind. ☿ 30 $\frac{6}{10}$.

24. Fair and pleaſant, with ſmall Gales at S E, the Afternoon calm, at Night moderate Gales from N N W. ☿ 30 $\frac{6}{10}$.

25. Fair and pleaſant, with moderate Gales at S S E and S E. ☿ 30 $\frac{6}{10}$.

26. Grey cloudy Weather, with drizling Rains all Day and Night, and moderate Gales at S E. ☿ 30 $\frac{6}{10}$.

27. Fair Weather, clearing up with ſmall Gales at S E.

28. Fair

28. Fair and pleaſant Weather, with ſmall Gales N W. In the Afternoon veering to W S W, and about to S E. ☿ 30 $\frac{6}{10}$.

1. Dry Weather, ſomewhat cloudy, with moderate Gales at S E. ☿ 30 $\frac{5}{10}$. *March.*
2. The Morning fair and very ſerene, the Afternoon overcaſt with ſmall Gales at S E. ☿ 30 $\frac{5}{10}$.
3. The Morning fair and ſerene, the Afternoon overcaſt with moderate Gales at E S E and S E. ☿ 30 $\frac{8}{10}$.
4. Grey cloudy Weather with moderate Gales at S E. At Night blowing freſh from N E. ☿ 30 $\frac{4}{10}$.
5. Grey cloudy Weather, with ſome Rain, and moderate Gales at S E. At Night ſome Thunder, Lightning and Rain. ☿ below 30.
6. The Morning ſerene and temperately warm, with ſmall Southwardly Breezes. The Forenoon and all Day overcaſt, in the Afternoon ſome Rain, cloſe hazy Weather with ſmall Gales at N by E and N. ☿ 30.
7. Grey cloudy Weather with ſmall Gales at E S E. At Night much Rain. ☿ 30.
8. Grey cloudy Weather, ſomewhat hazy, with moderate Gales at N. and N by E. ☿ 30 $\frac{4}{10}$.
9. Fair and pleaſant Weather in the Forenoon, with ſmall Gales at S E. ☿ 30 $\frac{6}{10}$. The Afternoon overcaſt, and little Wind all Night. ☿ 30 $\frac{5}{10}$.
10. Dry Weather, ſomewhat cloſe with ſmall Gales at S E, in the Evening ſome Rain. ☿ 30 $\frac{4}{10}$. In the Night much Wind and Rain.
11. Cloſe and cloudy Weather, with ſmall Rains and moderate Gales at N N W. ☿ 30 $\frac{4}{10}$.
12. Cloſe and cloudy Weather, with moderate Gales from S E to N E. ☿ 30 $\frac{4}{10}$.
13. Grey cloudy and cloſe Weather, with ſome Rain and ſmall Gales at S E. ☿ 30.
14. Grey, cloudy and cloſe Weather, with ſmall Gales variable from S E to N W. ☿ 30 $\frac{3}{10}$.
15. Very cloſe hazy Weather, calm all Day. ☿ 29 $\frac{17}{10}$. At Night ſmall Gales at W N W with ſome Rain.
16. Cloſe and cloudy Weather, with ſmall Gales from N W to N. ☿ 30.
17. Fair and ſerene Weather, with ſmall variable Gales. ☿ 30 $\frac{4}{10}$.
18. In the Morning overcaſt with moderate Gales at N W, preſently veering to S E, with drizling Rains all Day. ☿ 30 $\frac{3}{10}$, falling to 29 $\frac{17}{10}$.
19. Grey cloudy Weather, for the moſt Part calm. ☿ 29 $\frac{17}{10}$.

20. Very

20. Very thick foggy Weather all Day, with ſmall variable Breezes, for the moſt Part calm. ☿ 29 $\frac{17}{100}$.

21. In the Morning foggy, the reſt fair and ſerene Weather, with ſmall Southwardly Gales. ☿ 29 $\frac{18}{100}$.

22. The Morning fair and ſerene, the Afternoon overcaſt with ſome Rain and variable Gales. ☿ 30.

23. Grey cloudy Weather, the Afternoon and all Night drizling Rains and moderate Gales at N N E. ☿ 30.

24. Cloſe Weather with continu'd drizling Rains, and at Night much Rain with moderate Gales from N N E to N, and very cold. ☿ 30 $\frac{1}{100}$.

25. The Morning ſomewhat cloudy, the Afternoon ſerene, with moderate Gales at N. ☿ 30 $\frac{5}{100}$.

26. Dry Weather, ſomewhat cloudy, with ſmall variable Gales. ☿ 30 $\frac{4}{100}$.

27. Grey cloudy Weather, with ſmall variable Gales, ſometimes calm. ☿ 30 $\frac{2}{100}$.

28. Cloſe hazy Weather, with ſome Rain and ſmall variable Gales, ſometimes calm. ☿ 29 $\frac{18}{100}$.

29. The Forenoon grey cloudy Weather, the Afternoon very cloſe and hazy with much Rain. ☿ 29 $\frac{17}{100}$. Small variable Breezes, for the moſt Part calm.

30. Cloſe and cloudy Weather, with moderate Gales at N N E. ☿ 29 $\frac{18}{100}$. At Night riſing to 30, and the Gale freſhning.

31. Fair Weather, ſomewhat cloudy, with ſmall variable Gales. ☿ 30.

April.

1. The Forenoon overcaſt, Afternoon more ſerene, with ſmall Southerly Gales. ☿ 30 $\frac{1}{100}$.

2. Fair and pleaſant Weather, with ſmall Gales at S W. ☿ 30 $\frac{2}{100}$.

3. Grey cloudy Weather, blowing freſh in the Forenoon at N E. Afternoon moderate. ☿ 30 $\frac{4}{100}$.

4. Fair and ſerene Weather, the Horizon ſomewhat cloſe, with eaſy Gales at S. ☿ 30 $\frac{4}{100}$. In the Afternoon the Gale veer'd to W, and the Sky ſomewhat hazy.

5. Cloſe and cloudy Weather, with ſome drizling Rain in the Forenoon, and ſmall Gales from S to E S E. The Night calm and rainy. ☿ 30.

6. Cloſe foggy Weather, with drizling Rains and calm. ☿ 29 $\frac{19}{100}$.

7. Fair and pleaſant Weather, ſomewhat cloudy and calm. In the Evening ſmall Gales at E to N E. All Night cloſe foggy Weather. ☿ 29 $\frac{18}{100}$.

8. Cloſe foggy Weather, with ſmall Northerly Breezes, for the moſt Part calm. ☿ 29 $\frac{16}{100}$.

9. The Forenoon cloſe and cloudy, Afternoon fair and pleaſant, with ſmall Gales at N. In the Evening calm. ☿ 29 $\frac{19}{100}$.

10. Fair

10. Fair and pleaſant Weather, ſometimes overcaſt, with ſmall Gales from S W to S. ☿ 29 $\frac{18}{20}$.

11. Fair and pleaſant Weather, with ſmall Gales from S to S E. ☿ 30.

12. Fair Weather, ſometimes overcaſt, with moderate Gales at N. ☿ 30 $\frac{3}{20}$.

13. Dry Weather, ſomewhat hazy, with freſh ſharp Weſterly Gales, ☿ 30 $\frac{4}{20}$. In the Evening ſerene and little Wind. ☿ 30 $\frac{3}{20}$.

14. Fair and pleaſant Weather, with ſmall Gales at S E. ☿ 30 $\frac{3}{20}$.

15. Fair and pleaſant Weather, with ſmall Gales from S to S E. In the Evening calm. ☿ 30 $\frac{2}{20}$.

16. The Forenoon fair and pleaſant, with moderate Gales at S E. ☿ 30 $\frac{2}{20}$. In the Afternoon overcaſt, with ſome Rain and ſmall Gales at N W. ☿ 30.

17. The Forenoon fair and pleaſant, with moderate Gales at S E. ☿ 30 $\frac{2}{20}$. The Afternoon overcaſt, and the Gale freſhning at Night. ☿ 30.

18. Fair and pleaſant Weather, ſomewhat cloudy, with ſmall Gales at S E. ☿ 30.

19. Cloudy Weather, with a hazy Sky, and ſmall Gales at S E. ☿ 29 $\frac{18}{20}$.

20. Dry cloudy Weather, with fine Gales at S E. ☿ 29 $\frac{17}{20}$.

21. Grey cloudy Weather, with ſome Rain in the Forenoon, and ſmall Breezes at S E, for the moſt Part calm; the Afternoon fair. ☿ 29.

22. Cloſe and cloudy Weather, with hazy and calm; in the Afternoon ſome Rain and ſmall Breezes at S E. ☿ 29 $\frac{16}{20}$.

23. Dry Weather, ſomewhat foggy and cloudy, with ſmall Gales at S E. ☿ 29 $\frac{17}{20}$. In the Evening thick foggy Weather.

24. Grey cloudy Weather ſomewhat foggy, with moderates Gales at S E. ☿ 29 $\frac{17}{20}$. At Night much Fog.

25. Cloudy and foggy Weather, with fine Gales at S E. ☿ 29 $\frac{15}{20}$. At Night much Rain, Thunder and Lightning, with little Wind. ☿ 29 $\frac{14}{20}$.

26. Cloſe and cloudy Weather, with ſmall Gales at N W. ☿ 29 $\frac{15}{20}$. In the Afternoon ſomewhat hazy with ſmall drizling Rain.

27. The Weather clearing up with eaſy Gales at S E. ☿ 29 $\frac{17}{20}$. The Afternoon overcaſt, and in the Evening much Rain with ſome Thunder and Lightning, the Wind veering to N W, and back to S E. ☿ 29 $\frac{15}{20}$.

28. Grey cloudy Weather, with ſome Fog, and ſmall Gales from W to N W. ☿ 29 $\frac{17}{20}$.

29. Cloſe and cloudy Weather, with ſmall Gales from N W to N. ☿ 29 $\frac{17}{20}$. At Night ſome Rain.

30. Grey cloudy Weather, ſomewhat cloſe, with freſh Gales at N W. ☿ 29 $\frac{17}{20}$.

May.

1. A fair and ſerene Morning, with ſmall Breezes at W by S. ☿ 29 $\frac{18}{00}$. All Day and Night fair and pleaſant, with ſmall Breezes at N W. ☿ 29 $\frac{19}{00}$.

2. Fair and ſerene Weather, with ſmall Breezes at S E, and ſometimes calm. ☿ 30^{d}. In the Afternoon and all Night freſh Gales.

3. The Weather ſomewhat cloudy, with freſh Gales at S E. ☿ 29 $\frac{17}{00}$. In the Afternoon falling to 29 $\frac{14}{00}$. The Wind veering to W N W, had much Rain with Thunder and Lightning all Night.

4. The Morning cloſe foggy Weather, almoſt calm. ☿ 29 $\frac{17}{00}$. The Afternoon clear'd up, blowing freſh from N to N E. ☿ 30 $\frac{1}{00}$.

5. Fair and pleaſant Weather, ſomewhat cloudy, with moderate Gales at S E. ☿ 30^{d}.

6. Fair and pleaſant Weather, ſomewhat cloudy, with moderate Gales at S E. ☿ 29 $\frac{19}{00}$. Towards Noon little Wind. In the Afternoon a fine Gale at S E by E, and at Night thick foggy Weather. ☿ 29 $\frac{12}{00}$.

7. Grey cloudy Weather, ſomewhat foggy, with ſmall Gales at S E, ☿ below 29 $\frac{18}{00}$.

8. Fair and pleaſant Weather, ſomewhat foggy on the Hills, and ſmall variable Breezes from S W to N W. ☿ 29 $\frac{18}{00}$. At Night much Fog.

9. Fair and pleaſant Weather, with ſome Fog on the Hills, with ſmall variable Breezes from S W to N W. ☿ 30^{d}. The Afternoon ſerene.

10. The Forenoon fair and pleaſant, ☿ falling from 29 $\frac{18}{00}$ to 29 $\frac{17}{00}$. The Afternoon overcaſt with ſmall Gales from S to S E.

11. Grey cloudy Weather, with ſmall Gales N E. ☿ 29 $\frac{17}{00}$. In the Afternoon ſome Rain.

12. Fair and pleaſant Weather, ſomewhat cloudy, with ſmall Northerly Gales. ☿ 29 $\frac{18}{00}$.

13. Fair and ſerene Weather, with ſmall Gales at S W, ſometimes calm. ☿ above 29 $\frac{11}{00}$.

14. Fair and ſerene Weather, with ſmall Gales variable from W to N E. ☿ 30^{d}. The Afternoon ſomewhat overcaſt.

15. Fair and pleaſant Weather, with ſmall Gales at N E. ☿ 29 $\frac{18}{00}$. At Night calm.

16. Fair and ſerene Weather, with ſmall Gales from N E to S E. ☿ falling to 29 $\frac{17}{00}$. In the Evening overcaſt with ſome Fog.

17. The Morning ſome Fog on the Hills, all Day fair and ſerene, with ſmall Gales at S E. ☿ 29 $\frac{18}{00}$. At Night calm.

18. The Morning ſomewhat cloſe and foggy, all Day fair and pleaſant with fine Gales at S E. ☿ 30^{d}.

19. Fair and pleaſant Weather, with fine Gales at S E. ☿ 30^{d}.

20. Fair and pleaſant Weather, with freſh Gales at S E, the Sky ſomewhat hazy. ☿ 29 $\frac{18}{00}$.

21. Grey

21. Grey cloudy Weather, with freſh Gales at S E. ☿ falling below 29 $\frac{18}{20}$. At Noon ſome ſmall Rain.

22. Cloudy hazy Weather, with ſmall drizling Rains and moderate Gales at S E. ☿ below 29 $\frac{17}{20}$.

23. Cloſe and cloudy Weather, with moderate Gales at S E. ☿ 29 $\frac{16}{20}$.

24. Thick hazy Weather, with continual Rain, and freſh Gales from N N E to S E. ☿ falling below 29 $\frac{12}{20}$.

25. Cloſe and cloudy Weather, with moderate Gales from E to N E. ☿ 29 $\frac{13}{20}$.

26. The Forenoon thick hazy Weather, and the Afternoon grey cloudy Weather, with ſmall Gales at N E. ☿ riſing above 29 $\frac{14}{20}$.

27. Grey cloudy Weather, with moderate Gales at S E. ☿ above 29 $\frac{15}{20}$. Some Rain at Night.

28. Grey cloudy Weather, with the Wind from S to S S E, ſometimes ſmall Gales, and ſometimes blowing freſh. ☿ 29 $\frac{15}{20}$. Rain at Night.

29. Grey cloudy Weather, with fine Gales at S E, and drizling Rains. ☿ 29 $\frac{15}{20}$. At Night ſmall Gales at N E, ſometimes calm with thick Weather.

30. Thick foggy Weather, for the moſt Part calm, and ſmall drizling Rains. ☿ 29 $\frac{13}{20}$. At Night ſmall Gales at S E.

31. Grey cloudy Weather, ſomewhat foggy, with ſmall Gales at S E. ☿ 29 $\frac{18}{20}$. At Night ſome Rain.

June.

1. Grey cloudy and foggy Weather, with ſome Rain in the Forenoon, and ſmall Gales at W. ☿ 29 $\frac{13}{20}$. In the Afternoon, riſing to 29 $\frac{15}{20}$. The Winds veering to N, and the Weather clearing up.

2. The Forenoon fair and pleaſant Weather and calm. ☿ 29 $\frac{17}{20}$. The Afternoon overcaſt, with ſome ſmall Rain, and ſmall Gales at S E, ☿ falling below 29 $\frac{16}{20}$. At Night ſome Rain.

3. All this Forenoon cloſe thick rainy Weather, with ſmall Gales at N E, ☿ falling below 29 $\frac{13}{20}$. The Afternoon dry, cloudy and calm.

4. Fair and pleaſant Weather, with fine freſh Gales from S E to S S E. ☿ above 29 $\frac{14}{20}$.

5. Fair and ſerene Weather, very hot, with ſmall Gales from W S W to N W. ☿ above 29 $\frac{15}{20}$.

6. Fair and ſerene Weather, with variable Gales round the Compaſs. ☿ 29 $\frac{17}{20}$. The Afternoon ſomewhat cloudy, and at Night calm.

7. The Forenoon overcaſt and foggy, with ſmall Gales at S E, and ſince Noon drizling Rains. ☿ falling to 29 $\frac{14}{20}$. Much Rain in the Night, blowing in Guſts.

8. Cloſe hazy Weather, with drizling Rains all Day, and ſmall variable Breezes, for the moſt Part calm. ☿ 29 $\frac{13}{20}$. At Night fair.

9. This Morning clearing up, with ſome Drops of Rain and calm. ☿ riſing to 29 $\frac{16}{20}$. The Afternoon overcaſt, and ſome Rain in the Evening.

10. Grey cloudy Weather, ſomewhat foggy, with ſmall Gales at S E, ſometimes calm. ☿ 29 $\frac{18}{20}$. The Afternoon and Night drizling Rains.

11. This Morning cloudy and foggy, with drizling Rains and calm. ☿ below 29 $\frac{18}{20}$. The Afternoon cloſe and foggy, with drizling Rains and ſmall Gales from E S E to S E. ☿ falling to 29 $\frac{14}{20}$.

12. Cloſe foggy Weather, with little Wind at S E, and ſometimes calm. ☿ 29 $\frac{13}{20}$. The Afternoon and all Night very much Rain.

13. Cloſe foggy Weather, with much Rain in the Forenoon, and drizling in the Afternoon, with ſmall variable Breezes, ſometimes calm. ☿ 29 $\frac{13}{20}$.

14. The Morning cloſe and foggy, the Forenoon clear'd up, with fair and pleaſant Weather, and ſmall Breezes at S W. ☿ 29 $\frac{14}{20}$. The Afternoon overcaſt, with ſmall Gales at S E. In the Evening ſome vehement Thunder, with Lightning and much Rain. ☿ below 29 $\frac{14}{20}$.

15. The Forenoon cloſe foggy Weather, the Afternoon grey and cloudy, with ſmall Gales from S E to N E, ſometimes calm. ☿ below 29 $\frac{14}{20}$.

16. The Forenoon cloſe and foggy, with ſome Rain; at Noon cleared up with ſmall Gales from S E. ☿ above 29 $\frac{13}{20}$. At Night cloudy with ſome Lightning.

17. The Morning very hazy and calm, the Forenoon clear'd up with ſmall Gales at S E. ☿ above 29 $\frac{14}{20}$. The Afternoon overcaſt, with the Gale veering to N by E, much Rain, Thunder and Lightning. ☿ as before.

18. Grey cloudy Weather in the Morning, and cleared up in the Afternoon, with ſmall Gales at S E. ☿ 29 $\frac{16}{20}$. The Afternoon overcaſt with freſh Gales continuing all Night. ☿ as before.

19. This Forenoon grey cloudy Weather, ſometimes clearing up, with freſh Gales at S E. ☿ 29 $\frac{16}{20}$.

20. Fair and cloudy Weather, with moderate Gales at S E. ☿ 29 $\frac{17}{20}$.

21. The Forenoon fair and ſomewhat cloudy, the Afternoon ſerene and pleaſant, with ſmall Gales at S E. ☿ below 29 $\frac{16}{20}$.

22. The Forenoon fair and pleaſant, with fine Gales at S E. ☿ below 29 $\frac{16}{20}$. The Afternoon grey and cloudy, with little Wind.

23. Fair and pleaſant Weather, with ſmall Breezes at S E, for the moſt Part calm, with ſome Lightning in the Night. ☿ 29 $\frac{16}{20}$.

24. Fair and pleaſant Weather, with ſmall Gales at S E, ſometimes calm. ☿ 29 $\frac{16}{20}$. At Night overcaſt and calm, with ſome Lightning.

25. Fair and ſerene Weather, with ſmall Gales at S E, in the Forenoon. ☿ 29 $\frac{16}{20}$. The Afternoon fine freſh Gales from S E to S by E, and blowing very freſh all Night.

26. Fair

26. Fair and pleaſant Weather, blowing very freſh from S by E to S by W, about Noon little Wind. ☿ below 29 $\frac{16}{20}$. The Afternoon moderate Gales at S E.

27. Fair and ſerene Weather, with moderate Gales at S E. ☿ below 29 $\frac{16}{20}$.

28. Fair and ſerene Weather, with moderate Gales at S E. ☿ as before.

29. Fair and ſerene Weather, with fine Gales at S E. ☿ 29 $\frac{14}{20}$. The Evening overcaſt and blowing freſh all Night.

30. Cloudy Weather, and ſomewhat hazy, with freſh Gales from E S E to N E. ☿ below 29 $\frac{14}{20}$. The Afternoon much Rain and blowing hard all Night at S E. ☿ 29 $\frac{12}{20}$.

July.

1. Cloudy and hazy Weather, with ſome Rain and hard Gales at S E. ☿ 29 $\frac{12}{20}$.

2. The Forenoon fair and ſomewhat cloudy, the Afternoon ſerene, with fine freſh Gales at S E. ☿ below 29 $\frac{11}{20}$. All Night cloudy.

3. Dry Weather, ſomewhat cloudy, with fine Gales at S E. ☿ 29 $\frac{14}{20}$.

4. Fair and ſerene Weather, with fine freſh Gales at S E. ☿ 29 $\frac{14}{20}$. The Evening overcaſt.

5. Fair and pleaſant Weather, ſomewhat cloudy, with a ſmall Shower in the Forenoon, ſome Thunder and eaſy Gales at S E. ☿ above 29 $\frac{15}{20}$. At Night little Wind.

6. Fair and ſerene Weather, with ſmall Gales at S E. ☿ 29 $\frac{16}{20}$. At Night little Wind.

7. Fair and pleaſant Weather, ſomewhat cloudy, with fine Gales at S E. ☿ 29 $\frac{14}{20}$.

8. The Forenoon overcaſt, with ſome Rain and Guſts of Wind at S E; the Afternoon fair and pleaſant, with eaſy Gales at S E. ☿ above 29 $\frac{13}{20}$. At Night ſome ſmall Rain.

9. Fair and pleaſant Weather, ſometimes cloudy, with fine Gales at S E. ☿ above 29 $\frac{13}{20}$.

10. The Morning ſomewhat hazy and cloudy, all Day fair and ſerene Weather, with eaſy Gales at S E. ☿ below 29 $\frac{13}{20}$.

11. Fair and pleaſant Weather, with ſmall Gales at S E. ☿ below 29 $\frac{12}{20}$. The Afternoon overcaſt and little Wind. ☿ falling to 29 $\frac{11}{20}$. Some Thunder and Lightning.

12. The Forenoon fair and pleaſant, with ſmall Gales at S E. ☿ below 29 $\frac{10}{20}$. The Afternoon overcaſt, with ſeveral ſmall Showers of Rain and little Wind, all Night calm.

13. Fair and pleaſant Weather, with ſome Clouds and calm. ☿ 29 $\frac{12}{20}$. Towards Noon overcaſt, and the Wind in ſmall Gales veering to S W. with cloſe rainy Weather all the Afternoon, in the Evening dry and cloudy, with ſmall Gales at W. ☿ 29 $\frac{14}{20}$.

14. This Morning and Forenoon cloſe and cloudy Weather, with much Rain and ſmall Gales at W. ☿ 29 $\frac{14}{20}$. The Afternoon dry and cloudy, the Wind and ☿ as before.

15. Fair and pleaſant Weather, with ſmall Breezes from W to S W, ſometimes calm. ☿ 29 $\frac{16}{20}$.

16. Dry cloudy Weather, with ſmall Gales at S E. ☿ 29 $\frac{14}{20}$.

17. Fair and pleaſant Weather, ſometimes cloudy, with fine freſh Gales at S E by S. ☿ above 29 $\frac{14}{20}$.

18. Fair and pleaſant Weather, ſometimes overcaſt, with freſh Gales at S E. At Night blowing very hard. ☿ 29 $\frac{14}{20}$.

19. Fair and pleaſant Weather with ſmall Gales at S E. ☿ 29 $\frac{16}{20}$.

20. Fair and ſerene Weather, with fine freſh Gales in the Forenoon, and fine freſh Gales in the Afternoon. ☿ 29 $\frac{15}{20}$. At Night calm.

21. Fair and ſerene Weather, with fine Gales at S E. ☿ 29 $\frac{15}{20}$.

22. Fair and ſerene Weather, with fine Gales at S E. ☿ 29 $\frac{15}{20}$. At Night ſometimes little Wind, at other Times blowing freſh.

24. Fair and ſerene Weather, with fine Gales at S E. ☿ 29 $\frac{16}{20}$. Afternoon blowing freſh.

25. Very fair and ſerene Weather, with ſmall Gales at S E. ☿ 29 $\frac{17}{20}$. At Night ſome Lightning.

26. Grey cloudy Weather, with ſmall Gales at S E, at Night calm and ſome Lightning.

27. Grey cloudy Weather, with ſmall Gales at N N W in the Forenoon, veering to N E in the Afternoon. ☿ 29 $\frac{16}{20}$. At Evening much overcaſt, with Thunder, Lightning and ſome Rain.

28. Fair and pleaſant Weather, ſomewhat cloudy, with ſmall variable Gales from N W to N E. ☿ 29 $\frac{15}{20}$.

29. Grey cloudy Weather, with ſmall variable Gales from N E to S W, ſometimes calm. ☿ 29 $\frac{15}{20}$. In the Evening a ſmall Shower of Rain, with ſome Thunder and Lightning.

30. Fair and ſerene Weather and calm. ☿ 29 $\frac{17}{20}$. In the Afternoon ſmall Gales at N N W, very hot and ſultry; at Night little Wind with ſome Thunder and Lightning.

31. Fair and pleaſant Weather, ſometimes cloudy, with fine Gales at S E. ☿ 29 $\frac{16}{20}$. Some Thunder and Lightning in the Afternoon.

Auguſt. 1. The Morning ſomewhat overcaſt, all Day fair and pleaſant, with ſmall Gales at S E. ☿ 29 $\frac{16}{20}$. The Afternoon fine Gales.

2. Very fair and ſerene Weather, with fine Gales at S E. ☿ 29 $\frac{17}{20}$.

3. Fair and ſerene Weather, with fine Gales at S E. ☿ 29 $\frac{18}{20}$.

4. Fair and ſerene Weather, with fine Gales at S E. ☿ 29 $\frac{18}{20}$.

5. The Forenoon grey cloudy Weather and calm, the Afternoon ſerene with ſmall Gales at S E by E. ☿ 29 $\frac{18}{20}$.

6. Fair and ſerene Weather, with ſmall Gales at N N W. ☿ 29 $\frac{16}{20}$. The Evening overcaſt with ſome Lightning.

7. Fair Weather, ſometimes overcaſt, with freſh Gales from S to S S E. ☿ 29 $\frac{17}{20}$.

8. Fair and pleaſant Weather in the Forenoon, and cloudy in the Afternoon, with ſmall Gales at S S E. ☿ 29 $\frac{16}{20}$.

9. Fair and ſerene Weather, with ſmall Gales in the Forenoon, and freſhning in the Afternoon at S E. ☿ 29 $\frac{12}{20}$.

10. Fair and ſerene Weather, with ſmall Gales from S E to E by S. ☿ 29 $\frac{18}{20}$. At Night calm.

11. Fair and ſerene Weather, calm in the Forenoon, and ſmall variable Gales in the Afternoon, and Lightning at Night. ☿ 29 $\frac{18}{20}$.

12. Fair and ſerene Weather, with ſmall Gales at S S E, at Night calm and hazy. ☿ 29 $\frac{17}{20}$.

13. Fair and ſerene Weather, calm in the Forenoon, and ſmall variable Breezes in the Afternoon. ☿ 29 $\frac{18}{20}$.

14. Fair Weather, ſometimes overcaſt, with ſmall Gales at N W by W. ☿ 29 $\frac{15}{20}$.

15. Fair Weather, ſomewhat cloſe, and ſome Rain in the Afternoon, with ſmall variable Gales. ☿ 29 $\frac{15}{20}$.

16. Fair and ſerene Weather, calm in the Forenoon, and ſmall variable Breezes in the Afternoon. ☿ 29 $\frac{15}{20}$.

17. The Weather cloudy and overcaſt, with ſome Rain in the Afternoon, and ſmall variable Gales round the Compaſs. ☿ 29 $\frac{16}{20}$.

18. Grey cloudy Weather, with ſome Rain, and eaſy Gales at N E. ☿ 29 $\frac{16}{20}$. In the Night very freſh Gales from N E to S E, and ſometimes at N W.

19. Grey cloudy Weather, with ſome Rain, and freſh Gales from S E to E S E. ☿ 30 $\frac{15}{20}$.

20. Fair and pleaſant Weather, with fine Gales at S E. ☿ 29 $\frac{16}{20}$.

21. Fair and pleaſant Weather, with fine Gales at S E. ☿ 29 $\frac{16}{20}$.

22. Fair and ſerene Weather, with ſmall Gales at S E. ☿ 29 $\frac{18}{20}$.

23. Fair and pleaſant Weather, with ſmall Gales at S E. In the Afternoon ſomewhat cloudy, and the Gale freſhning. ☿ 29 $\frac{18}{20}$. In the Night blew very freſh.

24. Fair and ſerene Weather, with moderate Gales at S E. In the Evening much overcaſt, and at Night much Rain with ſome Thunder and Lightning. The Wind at N W. ☿ 29 $\frac{15}{20}$.

25. The Morning grey and cloudy, all Day fair and pleaſant, with ſmall Gales at N W. In the Afternoon veering to S E, and at Night calm. ☿ 29 $\frac{16}{20}$.

26. Fair and pleaſant Weather, with ſmall Gales at S E. ☿ 29 $\frac{16}{20}$.

27. Grey cloudy Weather, with drizling Rains this Morning and Forenoon; and fair in the Afternoon, with ſmall variable Gales. ☿ 29 $\frac{15}{20}$.

28. Fair and pleaſant Weather, with ſmall Gales from N to N E. ☿ 29 $\frac{17}{20}$. AtNight calm.

29. Fair pleaſant Weather, with ſmall Gales at N E. ☿ 29 $\frac{17}{20}$. At Night ſome drizling Rain.

30. Fair

30. Fair and pleaſant Weather, ſomewhat cloudy, with eaſy Gales at N E. ☿ 29 $\frac{16}{20}$.

31. Grey cloudy Weather, with ſome Rain, and moderate Gales at N E. In the Night blowing in Guſts. ☿ 29 $\frac{14}{20}$.

September.

1. Fair Weather, ſometimes overcaſt, with freſh Gales from N to N N W. ☿ 29 $\frac{14}{20}$.

2. Cloudy Weather, with ſome Rain, and bluſtering Gales at N N W. ☿ 29 $\frac{16}{20}$.

3. Fair and pleaſant Weather, with moderate Gales at N N W, ſometimes overcaſt and blowing freſh; at Night little Wind. ☿ 29 $\frac{16}{20}$.

4. Fair and pleaſant Weather, with ſmall Gales from N W to N. At Night calm. ☿ 29 $\frac{18}{20}$.

5. Fair and pleaſant Weather, with ſmall Gales at N. ☿ 29 $\frac{18}{20}$.

6. Fair and pleaſant Weather, with ſmall Gales at N and N by W. ☿ 29 $\frac{18}{20}$.

7. Fair and pleaſant Weather. with ſmall Gales at N by W and N N W. ☿ below 29 $\frac{18}{20}$.

8. Fair and pleaſant Weather, with ſmall Gales at N N W. ☿ below 29 $\frac{18}{20}$.

9. Fair and ſerene Weather, with ſmall Gales at N. ☿ 29 $\frac{18}{20}$.

10. Fair and ſerene Weather, with ſmall Gales at N. ☿ 29 $\frac{18}{20}$.

11. Fair and ſerene Weather, with ſmall Gales at S E, and at Night veering to E N E. ☿ 29 $\frac{18}{20}$.

12. Fair and ſerene Weather, with ſmall Gales at S S E. ☿ 29 $\frac{18}{20}$.

13. The Forenoon fair and pleaſant, the Afternoon grey cloudy Weather, with ſmall Gales at E S E. ☿ 30^d.

14. Grey cloudy Weather, with ſmall Gales from E S E to E N E, ſometimes calm. ☿ 30^d. In the Night variable Gales with ſome Rain.

15. Grey cloudy Weather, with ſmall Gales from N E to S E by E. ☿ 30^d.

16. The Morning cloudy and overcaſt, all Day clear'd up, with eaſy gentle Gales at S E. ☿ 30^d.

17. Fair and ſerene Weather, with moderate Gales at S E. ☿ 30^d.

18. Fair and ſerene Weather, with moderate Gales at S E. ☿ 30^d.

19. Fair and ſerene Weather, with ſmall Gales at S E. ☿ 29 $\frac{18}{20}$.

20. Cloſe hazy Weather, with ſmall Gales from N E. ☿ 30 $\frac{1}{20}$. In the Afternoon ſome Rain.

21. Grey cloudy Weather, with moderate Gales at N by E and N N E. ☿ 30 $\frac{3}{20}$. In the Evening little Wind.

22. Dry temperate Weather, ſomewhat grey and cloudy, with ſmall Gales at N by W. ☿ 30 $\frac{5}{20}$.

23. Fair and pleaſant Weather, ſomewhat cloudy, with ſmall Gales at N N W. ☿ 30 $\frac{4}{20}$.

24. Fair

24. Fair and pleaſant Weather, with ſmall Gales at N N W. ☿ $30\frac{3}{10}$.

25. Fair and pleaſant Weather, with ſmall Gales at N N W. ☿ $30\frac{1}{10}$.

26. Fair Weather, ſomewhat cloudy, in the Afternoon ſome Showers of Rain, and ſmall Gales from N N W to N W by W. ☿ $30\frac{3}{10}$, riſing at Night to $30\frac{4}{10}$.

27. Fair and cloudy Weather, with ſmall Gales from N N W to N. ☿ $30\frac{4}{10}$.

28. Fair and pleaſant Weather, with ſmall Gales from N by W to N by E.

29. Dry and cloudy Weather, with ſmall Gales at N N W.

30. Fair and pleaſant Weather in the Forenoon, with ſmall Gales at N N E, the Afternoon overcaſt with Guſts of Wind and ſome Showers of Rain.

October.

1. The Morning overcaſt, all Day fair and pleaſant, with ſmall Gales from N N E to N.

2. The Morning grey and cloudy, all Day fair and pleaſant, with ſmall Gales at N by W.

3. Grey cloudy Weather, with moderate Gales at N and N by E, ſometimes blowing freſh; at Night thick and hazy with ſome Rain.

4. Thick hazy Weather, towards Noon clear'd up, Afternoon overcaſt with Rain and dark Weather. Small Gales at N N E.

5. Grey cloudy Weather, with ſmall Gales at N N E, inclining to Rain.

6. Thick hazy Weather, with much Rain and ſmall Gales at N N E. ☿ below 30^{d}.

7. The Morning cloſe and cloudy Weather, with ſome Rain, and ſmall Gales at N and N by W. ☿ below 30^{d}. All Day thick hazy Weather, with drizling Rains.

8. Hazy Weather, with drizling Rains and ſmall Gales at N N E and N E. ☿ $30\frac{3}{10}$.

9. Cloſe hazy Weather, with drizling Rains, and ſmall Gales at N E. ☿ $30\frac{4}{10}$. ☿ at Night $30\frac{5}{10}$.

10. Cloſe and cloudy Weather, with ſome Rain, and moderate Gales at N E. ☿ $30\frac{5}{10}$.

11. Grey cloudy Weather, with ſome Rain at Night and ſmall Gales at N N E. ☿ $30\frac{6}{10}$.

12. The Morning ſerene, with ſmall Gales at N E. ☿ $30\frac{7}{10}$. The Afternoon grey cloudy Weather. ☿ $30\frac{6}{10}$.

13. Dry cloudy Weather, with ſmall Gales at N by E. ☿ $30\frac{6}{10}$. The Afternoon more ſerene and almoſt calm.

14. Grey cloudy Weather, with moderate Gales at N E, ſometimes blowing freſh. ☿ $30\frac{2}{10}$.

15. Grey

15. Grey cloudy Weather inclining to Rain, with moderate Gales at N by W. ☿ 30 $\frac{3}{10}$. At Night much Rain.

16. Grey cloudy Weather, with ſome Rain at Night, and freſh Gales at N and N by W. ☿ 30 $\frac{4}{10}$.

17. Grey cloudy Weather, with moderate Gales at N by E, blowing freſh in the Night at N N W. 30 $\frac{4}{10}$.

18. Fair and pleaſant Weather, with moderate Gales at N W by N. ☿ 30 $\frac{5}{10}$.

19. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{5}{10}$.

20. Fair and ſerene Weather, with ſmall Gales at W N W and W by N. ☿ 30 $\frac{5}{10}$.

21. Fair and ſerene Weather, with ſmall Gales at N E and N E by E. ☿ 30 $\frac{6}{10}$.

22. Fair and ſerene Weather, with ſmall Gales at N and N by E. ☿ 30 $\frac{6}{10}$.

23. Fair and ſerene Weather, with ſmall Northerly Breezes, ſometimes calm. ☿ 30 $\frac{3}{10}$.

24. A grey cloudy Morning, blowing freſh at N N W. All Day fair and pleaſant, with moderate Gales at N. ☿ 30 $\frac{5}{10}$.

25. The Forenoon overcaſt with fine freſh Gales at W N W, and ſharp Weather, the Afternoon more ſerene and ſmaller Gales. ☿ 30 $\frac{7}{10}$.

26. Fair ſerene Weather, with fine ſharp Gales at N N W. ☿ 30 $\frac{8}{10}$.

27. Fair and ſerene Weather, with ſmall Gales at E S E and S E, ſometimes calm. ☿ 30 $\frac{6}{10}$.

28. Grey cloudy Weather, with freſh Gales at N N W and N. ☿ 30 $\frac{8}{10}$.

29. Fair Weather, ſomewhat cloudy, with moderate Gales from N by W to N W. ☿ 30 $\frac{8}{10}$.

30. Grey cloudy Weather, with moderate Gales at N W. ☿ 30 $\frac{8}{10}$.

31. Fair and ſerene Weather, with moderate Gales at N by W and N. ☿ 30 $\frac{10}{10}$. Very cold.

November.

1. Fair and ſerene Weather, with ſmall Gales at W N W. ☿ 30 $\frac{6}{10}$.

2. Grey cloudy Weather, with ſome Rain in the Evening, and moderate Gales at N N W. ☿ 30 $\frac{5}{10}$.

3. Fair and ſerene Weather, ſomewhat hazy with very freſh Gales at N by W and N N W. ☿ below 30 $\frac{6}{10}$.

4. Fair and ſerene Weather, with ſmall Breezes at N by E. ☿ 30 $\frac{6}{10}$. At Night calm.

5. Fair and ſerene Weather, with ſmall Breezes at S E. Sometimes calm. ☿ 30 $\frac{6}{10}$.

6. Fair and ſerene Weather, with ſmall Breezes from W S W to W N W. ☿ 30 $\frac{5}{10}$.

7. Fair

7. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{10}$.
8. This Morning foggy; all Day ſerene, with moderate Gales from S W to N W. ☿ 30 $\frac{6}{10}$.
9. Fair and pleaſant Weather, ſometimes overcaſt, with moderate Gales at S E and E S E. ☿ 30 $\frac{4}{10}$. At Night little Wind and calm.
10. Fair and ſerene Weather, with moderate Gales at S E. ☿ 30 $\frac{5}{10}$.
11. Grey cloudy Weather, with ſmall Gales at N and N by W. In the Evening calm. ☿ 30 $\frac{2}{10}$.
12. Fair and pleaſant Weather, with ſmall Gales at N. In the Evening calm. ☿ 30 $\frac{4}{10}$.
13. Fair and pleaſant Weather, with ſmall Gales from S by E to S E. ☿ 30 $\frac{4}{10}$. At Night calm.
14. Grey and cloudy Weather, ſomewhat hazy, with moderate Gales from W N W to N W. ☿ 30 $\frac{5}{10}$.
15. Grey cloudy Weather, with freſh Gales at N N E, and ſome ſmall Rain. ☿ 30 $\frac{5}{10}$.
16. Fair and pleaſant Weather, with moderate Gales from S to S E. ☿ 30 $\frac{6}{10}$.
17. Grey cloudy Weather, with moderate Gales from S by W to E S E. ☿ 30 $\frac{5}{10}$. At Night blowing hard, and veering to N W, with much Rain.
18. Grey cloudy Weather, with freſh Gales at N W. In the Afternoon blowing very hard. ☿ 30^{d}.
19. Grey cloudy Weather, with moderate Gales at N W. ☿ 30 $\frac{6}{10}$. At Night riſing to 30 $\frac{10}{10}$.
20. Fair and pleaſant Weather, with ſmall Gales from N to E, and about to S E. In the Evening little Wind. ☿ 30 $\frac{10}{10}$, falling to 30 $\frac{6}{10}$.
21. Grey cloudy Weather, for the moſt Part calm, with ſmall Northerly Breezes. ☿ 30 $\frac{6}{10}$.
22. Grey cloudy Weather, with moderate Gales at N W. ☿ 30 $\frac{6}{10}$.
23. Grey cloudy Weather, with fine Gales at N W. ☿ 30 $\frac{6}{10}$.
24. Grey cloudy Weather, with eaſy Gales from W N W to N W. ☿ 30 $\frac{6}{10}$.
25. Grey and cloudy Weather, with eaſy Gales at N W. ☿ 30 $\frac{6}{10}$.
26. Fair and ſerene Weather, with ſmall Gales at N W, ſometimes calm. ☿ 30 $\frac{6}{10}$.
27. Thick hazy Weather, with drizling Rains, and at Night much Rain, with ſmall Southerly Breezes, for the moſt Part calm. ☿ 30 $\frac{2}{10}$.
28. Hazy Weather, with drizling Rains all Day and Night, and ſmall Gales from N to N N E. ☿ 30 $\frac{1}{10}$, riſing to 30 $\frac{3}{10}$.

29. Grey cloudy Weather, with ſmall Gales at N N E. ☿ 30 $\frac{5}{20}$.

30. Grey cloudy Weather, with fine Gales at N. ☿ 30 $\frac{8}{20}$.

December, 1701.

1. Grey cloudy Weather, and very cold with fine Gales at N. ☿ 30 $\frac{12}{20}$. Some Froſt at Night.

2. Dry Weather, ſomewhat cloudy, with moderate Gales at N N W. ☿ 30 $\frac{8}{20}$.

3. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$.

4. Fair and ſerene Weather, with ſmall Gales at N W and W N W. ☿ 30 $\frac{6}{20}$. At Night overcaſt.

5. Dry cloudy Weather, with moderate Gales at N by W. ☿ 30 $\frac{0}{20}$.

6. Fair and pleaſant Weather, with fine Gales from E to S E, and at Night calm. ☿ 30 $\frac{7}{20}$, falling to 30 $\frac{5}{20}$.

7. Grey cloudy Weather, with freſh Gales at N W and W N W. ☿ 30 $\frac{8}{20}$.

8. Fair Weather, ſomewhat cloudy, with freſh Gales at N W. ☿ 30 $\frac{12}{20}$.

9. Fair and pleaſant Weather, with fine Gales at N N W. ☿ 30 $\frac{11}{20}$.

10. Fair and ſerene Weather, with ſmall Gales at N W to N. ☿ 30 $\frac{11}{20}$. At Night calm.

11. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{1}{20}$.

12. Fair and ſerene Weather, ſometimes cloudy, with ſmall Gales at N W. ☿ 30 $\frac{2}{20}$.

13. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{7}{20}$. At Night calm.

14. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$. At Night calm.

15. Fair and ſerene Weather, with ſmall Gales at S S W. ☿ 30 $\frac{8}{20}$. At Night the Gale freſhned from S S E.

16. Grey cloudy Weather, with moderate Gales at S E. ☿ 30 $\frac{6}{20}$. At Night ſome Rain.

17. Grey cloudy Weather, with drizling Rains, and ſmall Gales at N W. ☿ 30 $\frac{5}{20}$. At Night calm.

18. Grey cloudy Weather, with moderate Gales at N W. ☿ 30 $\frac{6}{20}$. Some Sleet in the Night.

19. Grey cloudy Weather, with moderate Gales at N W. ☿ 30 $\frac{5}{20}$.

20. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{5}{20}$. At Night 30 $\frac{4}{20}$.

21. The Forenoon ſomewhat hazy and calm. ☿ 30 $\frac{5}{20}$. The Afternoon ſerene, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$.

22. Fair

22. Fair and ſerene Weather, freezing, with freſh Gales at N N W. ☿ 30 $\frac{11}{20}$.

23. Serene Weather, freezing hard, with freſh Gales at N N W. ☿ 30 $\frac{14}{20}$. At Night little Wind.

24. Serene Weather, freezing hard, with moderate Gales at W N W. ☿ 30 $\frac{11}{20}$.

25. Fair froſty Weather, with moderate Gales at N W. ☿ 30 $\frac{10}{20}$.

26. Fair froſty Weather, with ſmall Gales from W N W to N N W. ☿ 30 $\frac{10}{20}$. At Night Fog.

27. Fair and ſerene Weather, freezing with little Wind at N W, for the moſt Part calm. ☿ 30 $\frac{9}{20}$.

28. Fair and ſerene Weather, freezing with ſmall Breezes at N, and ſometimes calm. ☿ 30 $\frac{8}{20}$.

29. Fair and ſerene Weather, freezing with ſmall Northerly Breezes for the moſt Part calm. ☿ 30 $\frac{6}{20}$. At Night ſome Wind and Rain.

30. The Morning foggy, all Day fair and pleaſant, with ſmall Gales from S E to E by S. ☿ 30 $\frac{4}{20}$.

31. Cloſe and cloudy Weather, with drizling Rains, for the moſt Part calm. ☿ 30 $\frac{2}{20}$.

January, 1702.

1. Thick hazy Weather, with drizling Rains, for the moſt Part calm, with ſmall variable Breezes. ☿ 30 $\frac{2}{20}$.

2. Grey cloudy Weather, with ſome Rain, and ſmall Gales at N E. ☿ 30 $\frac{4}{20}$.

3. Grey cloudy Weather, with ſmall Gales at N and N N W. ☿ 30 $\frac{3}{20}$.

4. Grey cloudy Weather, with ſmall Northerly Gales. ☿ 30 $\frac{2}{20}$.

5. Grey cloudy Weather, with ſmall Northerly Gales. ☿ 30 $\frac{5}{20}$. Afternoon and Night ſerene.

6. Fair and pleaſant Weather, with moderate Gales at S E. In the Evening and all Night calm. ☿ 30 $\frac{2}{20}$.

7. Cloſe and hazy Weather, with ſmall Gales at E S E and S E, ſometimes calm. ☿ 30 $\frac{2}{20}$.

8. Cloſe and cloudy, in the Morning little Wind, towards Noon blowing ſomewhat freſh at N N W, and in the Evening moderate. ☿ 30 $\frac{2}{20}$, riſing to 30 $\frac{6}{20}$.

9. Grey cloudy Weather, with ſmall Northerly Gales. ☿ 30 $\frac{4}{20}$.

10. Grey cloudy Weather, with ſmall variable Gales, ſometimes calm. ☿ 30 $\frac{4}{20}$.

11. Fair and ſerene Weather, with ſmall Breezes at S E. ☿ 30 $\frac{5}{20}$.

12. The Weather overcaſt, with moderate Gales at W N W. ☿ 30 $\frac{6}{20}$.

13. Fair and pleaſant Weather, with moderate Gales at N W. ☿ 30 $\frac{10}{100}$.

14. Fair and ſerene Weather, with ſmall Gales at N. ☿ 30 $\frac{10}{100}$.

15. Fair and ſerene Weather, with ſmall Gales at S E. ☿ 30 $\frac{8}{100}$.

16. Grey cloudy Weather, with ſmall Gales from S S W to S E. The Afternoon cloſe and hazy, with ſome Rain. ☿ 30 $\frac{2}{100}$.

17. Cloſe hazy Weather, with moderate Gales from N W to N by W. ☿ 30 $\frac{2}{100}$. At Night little Wind. *The* Chineſe *New-Year began this Day.*

18. Cloſe and cloudy Weather and calm. ☿ 30 $\frac{2}{100}$. The Afternoon ſmall drizling Rains.

19. Grey cloudy Weather, with freſh Gales at N by W, and a little Snow. ☿ 30 $\frac{6}{100}$.

20. Grey cloudy Weather, with ſmall Gales at N W, the Afternoon ſerene, and freezing hard at Night. ☿ 30 $\frac{6}{100}$.

21. Fair and ſerene Weather, freezing, with ſmall Gales at N N W, for the moſt Part calm. ☿ above 30 $\frac{6}{100}$.

22. Fair ſerene Weather, freezing hard, with ſmall Northerly Breezes, for the moſt Part calm. ☿ 30 $\frac{8}{100}$.

23. Grey cloudy Weather and calm. ☿ 30 $\frac{6}{100}$.

24. Cloſe hazy Weather, with drizling Rains and calm. ☿ 30 $\frac{7}{100}$.

25. Grey cloudy Weather, with ſmall Gales at N E. ☿ 30 $\frac{6}{100}$. At Night little Wind and ſome Rain.

26. Cloſe and cloudy Weather, with ſmall Gales at N E. ☿ 30 $\frac{8}{100}$. At Night calm. 30 $\frac{2}{100}$.

27. Thick hazy Weather, with drizling Rains and ſmall Gales at N by E. ☿ 30 $\frac{1}{100}$, blowing freſh at Night.

28. Grey cloudy Weather, with freſh Gales at N N W. ☿ 30 $\frac{6}{100}$. At Night 30 $\frac{8}{100}$.

29. Grey cloudy Weather, with fine Gales at N W. ☿ 30 $\frac{8}{100}$.

30. Fair and pleaſant Weather, with moderate Gales at N W. ☿ 30 $\frac{7}{100}$.

31. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{100}$.

A Regiſter of the Weather *for* 1692. *by Mr.* J. Locke. n. 298. p. 1917.

IX. I herewith ſend you a Copy of my Regiſter of the Weather at *Oates* in *Eſſex*, from the 9*th* of *December* 1691, to the End of the Year 1692. I ſhall firſt explain ſome Things in the Table.

The *Firſt* Column having D at the Top, contains the *Day* of the Month.

The next with H, the *Hour* of the Day, which beginning from 1 of the Clock in the Morning, I count round in one continued Series to 24, which is 12 of the Clock at Night.

The

The Column *Ther* is that of the Thermoſcope, which was a ſealed one, whereof you will find a larger Account hereafter.

The Column *Bar* marks the height of the *Mercury* in the Baroſcope. The firſt Number is the Inches of its height, the ſecond Number marks the 20th Parts of an Inch above that Inch mark'd by the firſt Number.

The Column *Hyg* is that which marks the Moiſture of the Air. The Inſtrument I us'd was the Beard of a wild Oat, of which each Turn was divided into ſixteen Degrees.

The Column of the Wind mark'd the Point the Wind was in, but not always exactly, becauſe the Weathercock viſible out of my Window, was ſtiff, and turn'd not eaſily; nor was the Houſe it ſtood on ſituate exactly Eaſt and Weſt; ſo that it was not eaſy by the ſtanding of the Weathercock, to know exactly the Point of the Wind: Wherefore I contented my ſelf to ſet down barely one of the 4 Cardinal Points, when the Wind was pretty near it; and when it was more remote, the two Cardinal Points between which it was, putting the Letter of the Cardinal Point firſt to which it was neareſt; as when the Wind was between the South and the Weſt, if it were nearer the Weſt than the South, I writ W. S. and ſo of the reſt.

I mark'd beſides, the Force of the Wind, which I divided into four Degrees. 1. When it juſt moved the Leaves. 2. When it blew a pretty freſh Gale. 3. When it was hard and whiſtling Wind. 4. When it blew a Storm. Though theſe Diviſions were not made with that Exactneſs as they might have been, had one had an Inſtrument on purpoſe, yet they may give ſome Help to thoſe who would make Obſervations from ſuch Regiſters as theſe, (o) was when there was not Wind enough to move a Leaf as I could ſee.

As to the Weather, *Cloudy* ſignifies more of the Sky (viſible out of the Windows of my Study, which were Eaſt and South) cover'd with Clouds, than not. *Fair* the contrary. *Between* when it was uncertain whether more of the Sky was covered or clear. *Cover'd* when no part of the clear Sky appear'd. *Cloſe* when the Sky was cover'd with one uniform thick Cloud.

I have often thought that if ſuch a Regiſter as this were kept in every County in *England*, and ſo conſtantly publiſhed, many Things relating to the Air, Winds, Health, Fruitfulneſs, *&c.* might be collected from them, and ſeveral Rules and Obſervations concerning the Extent of Winds and Rains, *&c.* be in Time eſtabliſh'd, to the great Advantage of Mankind. From this ſolitary one there is little to be collected, beſides the ordinary Obſervation, which I ſet down commonly every Morning, there ſeldom happen'd any Rain, Snow, or other remarkable Change, which I did not ſet down.

N. B.

N. B. That the Thermoſcope mark'd 4, which I made uſe of till *Mar.* 7. 1701. was one of thoſe ſold by Mr. *Tompion*, wherein 0 mark'd Temperate, and the Figures from thence increaſing both upwards and downwards, ſhew'd the Increaſe of Heat and Cold from Temperate. *Sept.* 22. 1701. I began to uſe a new ſealed Thermoſcope, adjuſted to a Scale made by Mr. *John Patrick*, who places 0 at the Top, ſuppoſing it to be the Heat under the Line, and ſo the Figures increaſe downwards, with the Increaſe of Cold. Temperate being placed at 45. This Thermoſcope is mark'd 5 in my Regiſter.

	D.	H	Ther. 4.	Bar.	Hyg.	Wind.	Weather.
December, 1691.	9	16	1. 2	30. $\frac{4}{2}$ 0		S. 1	Fog.
	10	17	2. 1	4		S E 1	Fair.
	11	10	3. 1	4		S E 1	Fog.
	12	9	3. 6	3		E 1	Froſt, Cloſe.
	13	9	3. 4	30 0		E 1	Cloſe.
	14	9	3. 7	29.17		E 2	Froſt, Fair.
	15	9	4. 2	30. 0		E 3	Froſt, Fair.
	16	9	4. 4	4		E 3	Froſt, Fair.
	17	9	4. 6	6		E 1	Froſt, Fair.
	18	9	4.	5		N E 1	Cloſe.
	19	9	3. 3	3		N E 1	Fog, Thaw.
		24		29.19		1	Cloudy, a little Rain next Morning.
	20	10	3. 4	18		N 1	Cloſe.
	21	9	3. 6	19		N 1	Fog, Froſt.
	22	9	4.	18		N 1	Cloſe.
	24	10	2. 6	14		S W 2	Cloudy.
	25	21	2. 1	15			Fair.
	26	21	1. 7	13		W 3	Cloſe.
		24		12			Rain before next Morning.
	27	18	1. 6	6			
	28	16	2. 6	9		S W 2	Fair.
		22		8			Rain.
		24		7		S 2	Rain hard.
	29	9	3.	4			Cloſe, and ſome Time after Rain.
		19	2. 7	4			Snow beginning at 6.
	30	8	3. 7	10		N. W	Fair.
	31	9	4. 7	12		NW 0	Fair, hard Froſt.
		17	3. 3	10		SE 1	Cloudy, Thaw.

D	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
1	9	3. 7	9. 11	47	S E 1	Cloſe, Snow at 10.
2	9	3. 7	14	43	W 1	Fair.
3	9	3. 5	8	41	S 2	Clouds.
4	8	3. 6	11	43	S 1	Cloudy.
5	9	3. 7	13	43	S 1	Cloudy.
6	8	4. 3	11	36	S 2	Cloſe.
	16	4.	8	36	E 3	Cloſe.
	20	4. 2	6	41		Snow.
7	10	4. 1	7	45	E 2	Cloſe.
	4	3. 7	17			Cloſe.
8	9	4. 1	30.	45	N E 1	Cloſe.
9	9	2. 6	29 18	50	S 3	Cloſe.
	20		15			Rain.
10	9	2. 7	18	44	S W 1	Fair.
	12			26		In the Shade.
11	9	2. 6	30. 4	48	W N 1	Cloſe, with a little Fog.
	24	2. 5	30. 8	41		Very fair all the afternoon, now cloſe.
12	9	2. 7	9	44	N 1	Miſty.
13	9	3. 4	9	46	S 1	Cloſe.
14	9	3. 7	7	48	E 1	Fog.
15	9	4. 4	6	31	E 1	Fog, Froſt.
16	9	4. 5	2	45	N 1	Fair, hard Froſt.
17	10	4. 1	29. 18	43	N E 2	Cloſe, hard Froſt.
18	8	4. 1	12	35	N W 2	Fair, rain & ſnow for an hour about 16.
19	9	3. 7	9	44	N W 2	Snow till 13.
20	8	4. 5	5	43	N W 1	Fair. Some clouds. Snow in the aft.
21	9	5. 7	6		N 2	Fair. Snow in the afternoon.
22	9	5. 6	9	18	N W 2	Very fair, hard Froſt.
	10	6. 2	11			In a Northern Cloſet without Fire at any time.
	24	6. 5½				In the ſame Cloſet, very hard Froſt.
23	9	5. 7	11	31	N W 2	Fair, Snow a little at 14.
24	9		11	28	N W 1	Cloudy, hard Froſt.
25	9	5. 6	10	31	N W 1	Fair, hard Froſt.
26	9	6. 0	9	32	N W 1	Cloudy, hard Froſt.
27	7	5. 3	7	33	N 1	Cloudy, hard Froſt.
28	9	4. 6	4	33	N 1	Snow in the Night, and Snow ſtill.
29	9	5. 6	2	32	W 1	Cloſe, Snow all Afternoon.

January 1692.

N. B.

N. B. I ſuſpect that from the 23d to the 29th incluſively, the Hygroſcope has been counted 16 Degrees, *i. e.* one whole Turn too high, it being all that while very hard Froſt.

	D	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
	30	9	4. 4	2		NW 2	Snow.
	31	9	5. 3	8		NW 1	Cloſe.
February.	1	8	5. ⊙	10	19	W	Fog.
	2	9	5. 6	11	19	W 1	Fog.
	3	8	5. 7	11	20	W 1	Fog.
	4	9	5. 5	9		E 2	Cloſe.
	5	9	5. 4	7	26	E 3	Cloſe, Snow in the Evening.
	6	9	5. 1	29. 0	20	E 1	Snow.
	7	9	4. 6	2		N 1	Cloſe Fog, little Thaw at 12.
	8	9	4. 6	29. 0	40	NE 2	Fog, Snow in the Night.
	9	8	5. 3	29. 0		NE 2	Snow.
	10	9	5. 5	1		NE 2	Cloſe.
	11	8	6.	8		W 1	Fair.
	12	9	7. 0	11		NW	Cloſe, freezing exceſſively.
	13	9	4. 2	5		SW 1	Cloſe Thaw. It may be obſerv'd between the Thermoſcope to day and yeſterday Morning, there is the Difference of two whole Degrees and $\frac{6}{8}$ a greater Riſe than one ſhall ordinarily find. The Thermoſcope was unmov'd in a Corner of a very large Room, out of all reach of the Fire, whereby it might be alter'd.
	14			7			Cloſe.
	16	12		10			Cloſe.
	17	19		9			Fog.
	18	12		5		W	Snow.
	26	2		11		W 2	Cloſe.
	27	9	2. 3	29. 8		W 2	Fair, Rain from 15 to 19.
	28	9	3. 1	6		W 1	Cloſe, Snow laſt Night.
	29	9	3. 6	6		SW 2	Cloudy, Snow laſt Night.
March.	1	8	2. 7	28. 17		SW 3	Fair.
	2	8	3. 1	29. 5		SW 3	Fair.
	3	7	2. 6	8		WS 2	Fair.
		16	1. 4	8		WS 1	Rain very gently till 20, hard till 23.
	4	9	3. 1	14		NE 2	The Ground cover'd with Snow. Cloſe.

D.	H	Ther. 4.	Bar.	Hyg.	Wind.	Weather.
5	9	3. 4	18		W 2	Cloudy.
6	9	2. 4	11		W 2	Rain till 16.
	16	2. 0	9		W 1	Rain.
	22	2. 2	10			Fair.
7	9	3. 5	10		W 2	A little dropping.
	12		9		WN 2	Snow for ¼ Hour.
8	9	3. 3	14		W 1	Fair.
9	8	3. 3	15	25	SW 2	Fair.
10	9	6	19	17	S 1	Fair.
	17	2. 2	18	19	W 2	A little Rain.
11	9	1	19	25	WN 1	Cloſe.
12	9	5	30. 1	23	NW 1	Cloſe.
	14	2. 0	30 0	24	WN 2	Cloſe. Small Rain at 15 till 16.
	16	1. 7	29.19	40	WN 1	Very gentle Rain.
	23	7	16		NW 2	Hard Rain for 3 or 4 Hours paſt.
13	9	2. 3	13		WN	Very gentle ſmall Rain.
	12		11		NW 2	Fair.
14	9	2. 6	11	27	NW 2	Cloſe.
	16	5	13	25	NE 3	Fair.
15	8	4. 0	16	26	NE 2	Cloſe, Froſt laſt Night.
16	9	3. 4	14	25	NW 1	Cloſe.
	13	0	13	20	NW 1	Fair. Rain in the Night.
17	9	3. 0	8	25	NE 1	Cloſe.
	13		7		SE 1	Cloudy.
	18	2. 2	6		SE 2	Cloſe.
	19		5	29		Small Rain.
	23		4	35		Cloſe. Much Rain in the Night.
18	8	2. 3	1	41	WS 2	Cloſe.
19	9	6	3	34	SW 2	Cloudy. (dropping.
20	9	2	2	31	S 2	Cloudy. Rain laſt Night, Houſes yet
21	8	3. 3	3	29	0	Cloſe.
	14	1. 3	3	27	NE 2	A very little Shower.
22	8	3.	6	27	NE 1	Cloſe, a little, very little Snow in the Afternoon, ☿ riſing.
23	8	3. 5	10	26	1	Clouds.
	17	2. 7	10	20	SW 1	Cloſe.
24	8	3. 5	29.14	24	SW 1	Very fair, little Snow and Hail about 12, the ☿ falling a little.

	D.	H	Ther. 4.	Bar.	Hyg.	Wind.	Weather.
	25	8	2. 7	10	27	S W 2	Fair.
	26	8	1. 6	2	35	3	Rain very little at Night.
		12		5		S W 4	Cloſe.
		18	1. 0	7	29	S W 2	Cloſe.
		24		7	34	1	Hard Rain, the ☿ a little fallen.
	27	8	1. 0	7	37	W S 2	Cloſe.
		17	0. 2	2	33	W 1	Small Rain.
	28	7	0. 7	12	33	W 1	Cloſe.
		16	0. 5	12	30	W 1	Fair.
	29	8	1. 6	10	32	W 1	Rain. Rain a great deal laſt Night.
		13		8	2	N 1	Cloſe, miſling Rain all this Morning till now.
		15		7		N 1	Cloſe.
		22	1. 6	5	31		Fair.
	30	8	2.	1	32	W 2	Cloſe Rain laſt Night.
		15		2		N W 3	Rain as almoſt all this Morning.
		19		3		N W 3	Rain gently, as the great part of this Afternoon.
		24		6			Fair.
	31	9	3. 1	6	29	N W 1	Fair.
		24		3			Cloſe, Rain in the following part of the Night.
April.	1	9	2. 6	2	32	S 1	Small Rain.
		24		1			The greateſt Part of the foregoing Day gentle Rain.
	2	9	1. 7	28.16	39	S E 2	Cloſe, Rain a great deal laſt Night, ſo as to make a Flood.
		16	1	17		S W 2	Fair.
		24		19			Cloſe, Rain in the following part of the Night.
	3	9	2. 2	29. 0	23	N 2	Cloſe.
		14	1. 7	2	32	N W 3	Small Rain.
	4	8	3. 4	10	30	N 2	Fair.
	5	8	3. 2	19	26	N W 1	Cloudy.
		14	2. 1	19	26	N W 1	Rain, the ☿ a little riſen, the Rain laſted about an Hour.
		14	2. 1	19	26	S E 1	Rain.

D	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
	17	2. 1	19	26	S E 1	Rain.
6	8	3. 2	30. 3	27	N E 1	Cloudy.
7	8	3. 0	4	25	N 1	Fair.
	3		2	25		Cloſe.
8	8	2. 4	2	23	N E 1	Cloſe.
	42	1. 7	1	22		Cloſe.
9	8	2. 0	29. 19		N E 1	A little Fog.
10	9	3	30. 0	21	N E 2	Fair, $\frac{13}{16}$ | 23 $\frac{16}{13}$.
11	8	4	2	17	N E 1	Not a Cloud 16 | $\frac{15}{16}$.
12	8	2	1	12	N E 1	Scarce a Cloud 15 | $\frac{0}{13}$.
13	8	1. 4	34. 0	7	N E 1	Not a Cloud.
	1[illegible]	0. — 2	29. 19	3	E 1	Not a Cloud, but a thick Air called a red Wind.
14	[illegible]	1. — 0	16	10	N E 1	High Clouds.
	2[illegible]	0. — 3	15	8		Clouds.
15	7	0. — 3	15	9	N E 1	Very fair.
16	8	0	18	8	W 2	Very fair.
17	9	0. 3	17	6	S W 2	Very fair.
	23	0. — 6	16	7		Small Rain for a little while.
18	19	0. 1	15	18	S W 2	Cloudy.

In the Cloſet on the North ſide of the Houſe.

	1[illegible]	0. 3	14	16	S W 2	Cloſe.
	23	0. 2	14	18		Rain.
19	9	1. 0	15	18		Fair.
	16	0. 5	15	16	S W 3	Cloſe.
20	9	0. — 2	15	16	W 1	Fair.
	9	0 —	6	18	S W 2	Cloſe, a little Rain this morning.
21	23	0. 4	1	27	2	Rain, as it had been moſt part of the Day.
22	8	1. 1	29. 0	17		
30	24	2. 3	4	21	N E 3	Rain, and all the Day before Rain.
1	10	2. 2	8	29	N E 2	Cloudy.

In the Chamber on the South ſide of the Houſe,

2	8	2.	1	12	29	N W 2	Cloudy, Rain laſt Night, ☿ was at 23 laſt Night as now. *May.*
	18		3	11	27	1	Fair, two or three Showers ſince 8.
3	9	2		14	29	N E 1	Fair.

D	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
4	11	1.	14	26	NW 1	Fair.
5	8	2. 6	16	23	NW 2	Cloſe.
6	8	6	16	24	NW 1	Fog.
7	8	0. — 2	14	21	W 1	Fair.
	19		13			Rain.
8	9	0 — 3	17	16	NE 1	Cloudy.
9	8	0. — 2 1	19	13	NE 1	Fair.
10	7	2. 2	19	12	NE 2	Fair.
13	17	0 — 2	19	5	NE 2	Fair.
14	10	1. 0	19	12	NE 2	Fair.
15	9	0 — 3 4	19	12	NE 1	Rain a little.
	16	0 —	19	13	NE 1	A few Drops, the ☿ ſunk a very little.
16	7	0	17	13	E 1	Fair.
17	8	0 — 4	29.14	8	NE 1	Not a Cloud.
18	7	0 — 6	29.12	5	S 1	Clouds, a little Shower about 10.
19	9	0 — 5	12	6	W 2	Cloudy, *i. e.* more Clouds than clear Sky.
20	9	3	10	5	SE 1	Cloudy.

N. B. Cloudy ſignifies more of the Sky cover'd than clear. Fair ſignifies more open Sky than cover'd with Clouds.

21	9	0	9	6	SW 1	Cloudy.
	18	0 — 2	9	5	SW 1	Rain for about an Hour.
22	8	0 — 1	12	6	NE 1	Cloſe, *i. e.* the Sky no where to be ſeen for Clouds; a Shower about 17.
23	6	0 — 2	18	7	W 1	Fair, *i. e.* more Sky than Clouds.
	9	2	18	8	SW 1	Very fair.
	15	1 — 1	18	7	WN 2	Hard rain about ¼ of an Hour.
	17	1. 1	18	7	SW 2	Hard rain.
24	7	0 — 4	17	8	NE 1	
25	8	5	14	8	SE 1	
26	8	1. 1	10	6	EN 1	
	18	3	10½	8	NE 2	Cloſe, a Thunder Shower at 19 the ☿ being riſen to 11.

D	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
27	7	7	12	7	N E 2	Cloſe.
28	7	0 1	14	7	N E 2	Cloudy.
	12	0 7	14	9	N E 2	Cloudy.
29	8	1. 1	13	10	W 2	Cloudy.
	13	1. 3	13	10	W 2	Rain.
30	6	0 2	15	8	W S 1	Cloſe.
	11	0	13	8	S W 3	Rain till Night.
	14	0 1	11	9	S W 3	Rain.
	21	3	3	14	3	Rain hard.
	24	3	29.	17	4	Cloſe.
31	7	0 3	1	14	W 4	Cloudy.
	24		2		W 4	Cloudy.
	24	1	4	12	2	Fair.
1	70	4	6	12	W 3	Fair.
2	70		4	13	W 2	Cloudy.
	100	1	4	13	W 4	A ſhower for about half an Hour, and then fair and calm again, at 11 Rain again, the ☿ a little raiſed. Several Showers in this day.
3	8	0 $\frac{1}{2}$	13	14	W 1	Cloſe.
	9	0	14	14	W 1	Rain a little.
4	6	0	14	13	S 1	Fair.
	23	0 7	7	13	1	Cloſe.
5	9	0 5	$4\frac{1}{2}$	13	S W 3	Cloudy.
	12	6	4	14	S W 2	Hard Rain $\frac{1}{4}$ hour, ſeveral ſuch Showers this Afternoon.
6	7	0 5	29. 5	14	S W 1	Cloudy.
	10	0 3	5	14	S W 2	Hard Rain $\frac{1}{4}$ hour.
7	7	0 3	6	13	S E 2	Betwixt Cloudy and Fair.
	11	0 1	6	13	S E 2	Hard Rain $\frac{1}{4}$ Hour, and a very great Shower 1 Hour, ☿ ſtanding as it was.
8	8	0 4	7	13	0	Fair. (all this morn.
9	9	0 1	$6\frac{1}{2}$	15	W S 1	Rain a good part of laſt night, and
	24	0 6	11	18	2	Rain all the afternoon till 20 or 21,
					0	the ☿ all the while riſing, now cloſe.
10	9	0 4	12	18		Cloſe, Rain the paſt morning.

June.

D	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
11	9	o	13	19	S W 2	Cloudy.
	11	o	14	19	S W 2	Rain ¼ Hour.
12	9	o	17	17	S W 2	Very Cloudy.
13	8	o	17	19	W 1	Cloudy.
14	8	1. 1	16		W 1	Cloudy.
15	7	1. c	15	18	N 1	Very Fair.

July. In my Abſence, the Thermoſcope being obſerv'd, it was found from the 15*th* of *June*, to the 11*th* of *Auguſt*, never to get ſo high as 3, and was very often below Temperate; ſo cold was this Summer.

Auguſt. 13	19	2	6	29 10			Cloudy, Rain about 21.
14	9	1	5	29 10		SW 2	Cloudy.
	11	1	6	29 10	17	SW 2	Rain.
	23	1	0	12	17		Fair.
15	9	1	2	8	25	E 2	Cloudy, Rain laſt Night.
	12	1	5	7	26	S E 2	Rain.
16	8	o		12	25	W 2	Fair.
17	8	o		15	21	S E 1	Fair.
18	7	1	1	14	22	S W 1	Cloudy.
	24	2	1	13	22		Small miſty Rain.
19	9	1	4	15	22	W 2	Cloſe.
20	8	1	1	18	20	S W 1	Very Cloudy.
21	8	1	0	16	19	S 1	Fair.
	10	1	3	16	19	W 1	Very ſmall rain.
	12	1	5	16		W 1	Very Cloudy.
22	8	1	6	18	18	NW 2	Fair.
23	9	o		30 0	16	SW 1	Not a Cloud.
24	8	o		30 0	15	0	Not a Cloud.
25	8	1	1	29 19	15	S W 1	Not a Cloud. (ſince yeſterday morn.
26	8	1	2	16		S E 1	Not a Cloud, ☿ gently ſinking ever
	17	3	5	16		1	Fair.
27	7	1	5	14	12		Thick Fog.
28	8	1	1	29 16	12	NW 2	Very fair.
29	9	o		16	10	NW 1 rac.SE	Very Cloudy.

D.	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.	
	17	1. 3	15	12	0	Cloſe, ſome ſmall Drops.	
30	8	1 1	13	12	NW 2	Cloſe.	
	20	0. 0	12	13	NE 1	A little Rain.	
31	8	0 2	13	12	NW 1	Very fair.	
1	9	1. 0	11	13	SW 3	Cloudy.	*September.*
	12	1. 3	11	13	SW 3	A little Rain.	
	14	1. 4	11	13	SW 2	Hard Rain for 1 Hour, and ſoft till 17.	
2	3	0 2	14	11	W 2	Fair.	
3	9	0 6	14	10	W 2	Cloudy.	
4	8	2. 0	15	8			
5	8	1. 6	16			Very fair.	
18	22	0 6	29.11		W 2		*October.*
19	9	0	4		S 3	Rain.	
20	9	1. 2	5		SW 2	Very fair.	
	18	0 3	2	16	SW 4	Rain.	
21	9	1. 4	10	17	WN 2	Not a Cloud.	
	24	0 5	15	16		Rain.	
22		0	16	37	WS 3	Cloudy.	
	16	0 3	17	33	WS 2	Cloudy.	
23	9	0 3	17	33	SW 1	Cloudy.	
	15	0 3	16	24	SW 1	Fair.	
24	9	0 5	15	27	SW 2	Fair.	
	14	0 1	16	30	SW 1	Small Miſt.	
25	8	0 5	30.	30	W 2	Cloſe.	
	15	0 3	29.19	29	W 2	Scarce a Cloud.	
26	9	0 5	16	28	W 1	Cloudy.	
27	9	1. 1	13	27	W 1	Cloſe.	
	23	0 7	13	27	1	Cloſe, a little miſling Rain good part of the Afternoon.	
28	9	1. 0	15	28	NW 1	Cloudy.	
29	9	1. 1	17	28	E 1	Cloſe, a little Fog.	
		0 7	18	29	E 1	Cloſe, a little gentle Rain about 15.	
30	9	2. 1	30. 1	26	E 2	Cloudy.	
31	8	3. 0	29.19	18	NE 1	Fair.	
	11	2. 6	18	19	NE 1	Hard Snow, which laſted till paſt Midnight.	

	D.	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
November	1	9	3. 5	29. 9	19	NE 1	Fair, ſcarce a Cloud.
	2	11	4. 0	7	20	SW 1	Froſt.
		15	3. 6	7	20	SW 1	Snow, which began at 13, and laſted to 20.
	3	9	3. 5	7	23	W 1	Cloſe.
		12	3. 0	5	25	WS 1	Rain, which began at 11, and laſted till 17.
		24	2. 0	1	39	3	Cloſe, Rain before 1, and ſo the greateſt Part of the Night.
	4	9	1. 5	3	40	S 2	Cloſe.
	5	9	1. 4	13	36	NE 1	Cloſe, Rain laſt Night.
	6	9	2. 0	15	33	NE 1	Cloſe.
	7	8	2. 2	16	32	NE 0	Cloſe.
	8	9	2. 1	14	32	EN 1	Cloſe.
		16	2. 0	14	33	NE 1	Rain, which began at 14, and continued till 24.
	9	9	2. 2	13	33	N 2	Small Rain but for a very little while.
	10	9	2. 4	17	32	NW 1	Not a Cloud.
	11	9	2. 4	17	30	W 1	A little Fog.
		16	1. 6	14	32		Hard Rain.
	12	9	1. 5	10	33	W 1	Rain.
	13	9	3. 1	4	30	W 0	Fair, Froſt.
	14	9	4. 2	12	28	NW 2	Very fair hard Froſt.
	15	9	4. 6	16	26	W 0	Very fair hard Froſt.
	16	10	4. 1	8	31	S 3	Cloſe, Snow laſt Night from 11 the greateſt Part of this Day.
	17	9	3. 7	8	34	S 1	Very Cloudy.
		13	3. 0	6	35	SW 2	Rain.
	18	8	4. 0	10	37	0	Fog, in the Cloſet on the North ſide of the Houſe.
	26	22	4. 2	18		3	Cloſe, in the Cloſet on the North ſide of the Houſe.
	27	10	4. 4	16	34	E 2	Cloudy.
	28	9	4. 6	18	32	E 3	Fair, Froſt.
	29	9	4. 6	16	31	E 3	Cloſe, Froſt.
	30	9	4. 5	18	33	E 3	Cloudy, Froſt.

D.	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.	
1	9	4. 5	30. 0	33	E 2	Rain mix'd with Hail, the Rain as it fell froze, and continued miſling till 14 or 15.	*December.*
2	9	4. 1	30. 0	38	SE 2	Rain, which began laſt Night, and laſted all this Day.	
	17	3. 4	29.17	39		Fog.	
3	9	3. 6	19	45	SW 0	Thick Fog Froſt.	
4	9	2. 6	5	48	S 2	Rain all the Morning.	
	12	2. 3	3	49	SW 2	Cloudy.	
5	10	2. 4	5	54	SW 2	Cloudy.	
6	11	2	7	53	W 2	Cloudy, ſome Rain this Morning.	
7	9	3	3	54	W 2	Cloſe.	
8	9	1. 4	28.18	56	SW 4	Rain and Stormy Wind all this Day.	
	23	6	15	58	SW 4	Hard Rain.	
9	9	4	16	55	SW 3	Cloudy.	
	17	5	15	53	3	Hard Rain.	
	24	2. 1	15	52	3	Fair.	
10	10	2. 4	29. 1	52	SW 1	Very Cloudy.	
	24	3. 1	11	52	0	Very Fair.	
11	9	3. 4	13	53	W 0	Very Fair.	
	18	2	13	52	E 1	Very Fair.	
12	10	3. 0	10	54	S 3	Cloſe.	
	15	2. 6	6	53	SE 3	Rain a little and ſhort.	
13	9	3	4	54	SE	Cloſe.	
14	9	1. 6	5	56	S 2	Rain all Day.	
	18	1. 4	3	57	2	Rain yet.	
15	9	2. 0	11	56	W 1	Very Fair.	
	15	1	13	56	W 1	Thick Fog.	
16	9	4	11	54	S 2	Cloſe.	
	15	2. 0	11	57	SW 2	Rain from 12.	
17	9	1. 6	14	56	SW 1	Cloudy.	

In my Chamber on the South ſide of the Houſe.

	11	1	15	54	WN 1	Fair.
	17	4	17	49	WN 1	Fair.
18	10	2. 7	30. 3	43	E 0	Very Fair, Hoar Froſt.
19	9	3. 2	0	43	S 0	Miſt. A Miſt is when the Drops manifeſtly fall.

D.	H	Ther. 4.	Bar.	Hyg.	Wind.	Weather.
20	8	2. 6	29.17	45	N E 0	Miſt, as it was all Day yeſterday.
21	9	4	12	46	S W 2	Cloſe.
	19	1	4	48	S W 3	Rain.
22	9	1	6	48	S 1	Not a Cloud.
	24	5	0	42	3	Rain.
23	9	3	28.10	51	W 4	Rain, which had been all Night.
24	10	3. 2	19	45	W 1	Cloſe.
25	11	3. 3	29.12	40	W 1	Fair, Froſt.
26	9	2. 0	3	57	S W 3	Rain all laſt Night.
27	9	6	3	51	S 3	Cloſe.
	11	2	0	51	S W 4	Cloſe.
	12	1	28.19	51	S W 4	Rain all Day.
28	11	3. 2	18	48	S W 2	Rain.
29	9	6	29. 6	48	S 1	Fair, Froſt.
	24	2	28.19	47	S 4	Rain.
30	9	2. 3	11	57	W 4	Rain very hard all laſt Night till now.
	24	3	17	48	4	Fair.
31	9	6	15	46	W 4	Not a Cloud.
	20	5	29. 8	39	2	Rain.
	24	4	10	40	1	Cloudy.

Obſervations on the Weather, Rain, Barometer *for* 1699, 1700, 1701, 1702, *by Mr.* W. Derham. n. 286. p. 1443.

X. 1.] Mr. *Townley* having commuaicated to me an Account of the Weather, *&c.* I ſhall compare my Obſervations on that Subject, made at *Upminſter* in *Eſſex*, with thoſe which he made at *Townley* in *Lancaſhire*.

As to the moſt remarkable Weather, eſpecially Rain of 1702, and the Effects thereof: Mr. *Townley* tells me, that it is a general Complaint in the North of *England*, that there were but ſmall Crops of Hay, which Calamity befel the Southern Parts alſo; the Cauſe whereof may be perceiv'd by the following firſt Table of Monthly Rain; in which the growing Months of *March* and *April* appear to have been dry Months in *Lancaſhire*, and *May* no wet Month, conſidering the Quantities of the other Months, and of other Years. Here at *Upminſter*, *April* was fortunately a wet Month, till the 23*d*, or elſe, no doubt, we ſhould have ſuffer'd more than we did in the Want of Hay; for the growing Month of *March* was a dry

dry Month, by the following Table; and *May* (which by the ſame Table ſeemeth to have had near a due Quantity of Rain) was a very dry Month: For very little Rain fell from *April* 23. till *May* 29. and then fell in great Showers, the greateſt Quantity of that Months Rain. Mr. *Townley* doth not tell me particulars, but I gueſs it to have been after this manner with them in the North of *England*; for beſides that *March* and *April* were dry Months with them, and *May* ſomewhat more wet; yet probably the Wet of *May* did not fall early in *May*; for it appears by the following Table the third, that the *Mercury* was high, and in ſomewhat a fix'd Station on *May* 13.

Thus much for the Weather in the Spring-Months of the Year 1702. and the Effects it had on Hay, which Effects I have ſome reaſon to think extended to many Parts of this Kingdom.

As to the other Months, there is little remarkable, beſides the vaſt Diſproportions of Rain between *Lancaſhire* and *Eſſex*, which I ſhould ſcarce take notice of, if it was not what happeneth almoſt every Year, as will appear by the following Table *1ſt*: The Cauſe of this I cannot judge of, unleſs it be that *Lancaſhire* is a more Hilly Country than *Eſſex*, which ſort of Lands, as they more need Wet than Vales and low plain Countries do, ſo have greater ſhares of it than theſe have; and perhaps ſomething may be attributed to the Weſtern Situation of *Lancaſhire* near the Sea; from which Quarter the Winds in *England* blow more than from the Eaſtward.

At the Foot of the Table of Rain, beſides the Quantity which fell in each Year, I have added the Depth thereof in Inches; or what Depth it would have been of, if the Earth had not imbib'd it, but it had ſtagnated on the Surface thereof.

I have added two Tables more, of the Stations of the *Mercury* in the *Barometer* at *Townley* in *Lancaſhire*, and at *Upminſter* in *Eſſex*, with the Differences thereof; and this obſerv'd at three times of the Day, *viz.* in the Morning, and about three in the Afternoon at *Townley*, but at Noon at *Upminſter*, and at nine a Clock at Night. One Table to the firſt Day of every Month; the other the moſt remarkably low, high and more ſettled Stations of the ☿ the laſt Year 1702.

By theſe *Barometrical* Tables it may be ſeen how far true that Opinion is of ſome learned Men, *viz. That the* ☿ *aſcendeth and deſcendeth in all Places at the ſame time, and in the ſame Proportion.* It is manifeſt, that the ☿ doth commonly riſe and fall in one diſtant Place, when it doth ſo in another, but not alike: Alſo when any conſiderable Variation is in one Place, it is ſo in another; when remarkably high, remarkably high; when low, low; when a great

The Mercury *riſes and falls in* all Places *at the* ſame Time, *but not in the* ſame Proportion.

Aſcent or Deſcent, generally the ſame elſewhere; but only the Differences of all theſe are not in equal Proportion in all Places; all which ſeemeth reaſonable to be expected, by reaſon of the Difference of Weather in different Places, eſpecially as to wet and dry.

A remarkable Deſcent *of the* Mercury.

There is one thing more in the following third Table, which I think deſerves Remark, becauſe I believe it to be the moſt conſiderable Alteration of the Mercury, that hath ever happen'd ſince the Invention of the *Baroſcope*, and that was the Deſcent on *Febr. 3d.* and *4th* 1702. concerning which, Mr. *Townley* in a former Letter gives me this Account, " That on *Febr. 3d.* the ☿ was at three in the Morning at 29. 15. at " 3h. 28. 50. and at 10 at Night at 27. 5. The next Day it fell yet " lower, and about 12 was at the loweſt, *viz.* 27. 39; but for an " Hour before, and as much after, it varied only ſo much as to make " it ſenſible that it was fallen, and began to riſe again; the loweſt he " had ever ſeen it before was on *Nov.* 18, 1674, when it fell to 27. 63 " That Mr. *Flamſteed* at the Obſervatory obſerv'd as remarkable a De- " ſcent of his ☿; and that it happen'd about the ſame Time of the " Day, *viz.* two of the Clock in the Afternoon at both Places.

And *laſtly*, he tells me, " That the Deſcent in *Febr.* laſt was the " greateſt that has been ſince the filling his Tube, which was in *March* " 1665". The particulars which I obſerv'd here at *Upminſter* about that Deſcent were, That on *Febr.* 2. the ☿ was high, *viz.* 29. 80. the next Morning 29. 50. at Noon 29. 16. at Night 28. 43. the next Morning, *(viz. Febr.* 4.) at ſeven of the Clock, it was fallen to 28. 5. and was globoſe, as if it had riſen, or was inclin'd to riſe: But it continu'd in the ſame Station till Afternoon, and then began to riſe about two of the Clock, and roſe haſtily. The Weather accompanying was fair on *Febr. 3d.* in the Morning, hazy at Noon, and Rain at Night, and a violent Tempeſt in the Night, and all the next Morning, of *Febr. 4th.*

TABLE I.

A Table, ſhewing how many Pounds, and Centeſimals of a Pound *Troy* of Rain, fell at *Townley* in *Lancaſhire*, and at *Upminſter* in *Eſſex*, in each Month of the Years 1699, *&c.* with the Quantity and Depth every Year.

	1699.		1700.		1701.		17 02.	
	Townl.	*Upmr.*	*Townl.*	*Upmr.*	*Townl.*	*Upmr.*	*Townl.*	*Upmr.*
Januar.	17 91	8 91	20 84	3 91	22 41	14 96	21 10	9 81
Febru.	32 70	60 5	19 12	7 64	16 78	8 78	21 27	7 30
March	17 92	5 63	7 58	1 55	7 10	3 91	2 48	2 37
April	10 47	3 44	18 65	7 60	6 11	1 43	5 34	10 90
May	4 00	2 67	17 92	6 91	19 67	9 11	8 81	6 49
June	10 37	40	13 15	7 60	11 34	5 79	23 00	13 46
July	16 51	6 36	15 26	4 24	17 58	9 49	25 31	43 9
Auguſt	19 77	8 57	12 05	8 14	23 66	6 57	20 12	6 88
Sept.	16 53	8 06	23 52	14 85	21 30	5 63	23 01	8 05
Octob.	18 90	13 49	26 44	17 15	24 59	10 21	28 57	7 92
Nov.	14 65	1 91	13 69	5 24	25 60	8 22	37 11	14 05
Decem.	16 78	5 77	26 88	10 30	10 19	9 35	41 63	10 27
Total	196 51	75 55	215 30	95 13	206 33	93 45	257 75	101 89
Depth	39 302	15 110	43 060	19 026	41 266	18 690	51 55	20 378

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TABLE II.

A Table ſhewing the Height of the ☿ at *Townley* and *Upminſter*, on the firſt Day of every Month in the Year 1702, three times a Day, *viz.* about 7 in the Morning, and 9 at Night; and about 3 Afternoon at *Townley*, with the Difference of the ☿'s Variation, and its difference between both Places.

First Day of the Mon.	☿ Heig. at Town.	☿ Heig. at Upmr.	Daily differ. at Town.	Daily differ. at Upmr.	☿ lower at Town.
	29 06	29 28			22
Jan.	28 90	21	16	07	31
	58	10	32	11	52
	29 58	96			38
Feb.	40	91	18	05	51
	30	80	10	11	50
	36	68			32
Mar.	36	66	00	02	30
	40	58	04	08	18
	70	79			09
April	68	73	02	06	05
	69	79	01	06	10
	20	51			31
May	9	49		02	
	09	44	11	05	35
	5	78			22
June					
	61	82	05	04	21
	84	98			14
July	90	30 01	06	03	11
	92	11	02	01	19
	62	29 80			18
Aug.	49	74	13	06	25
	47	67	02	07	20
	92	30 09			17
Sept.	95	12	03	03	17
	95	11	00	01	16
	56	29 74			18
Octob.		76		02	
	54	75	02	01	21
	46	71			25
Nov.	50	75	04	04	25
	58	76	08	01	18
	35	50			15
Dec.		34		16	
	10	09	251	25	01

TABLE III.

A Table ſhewing the *Loweſt Stations* of the ☿ in the Year 1702. at *Townley* and *Upminſter*; with the Difference of the ☿ at both Places.

Day of the Month	☿ at Town.	☿ at Upmr.	Differ.
	29 15	9 50	35
Feb. 3	28 50	16	66
	27 50	20 43	93
		05	
4	39	05	66
		62	
	77	18	31
Dec. 23	71	12	41
	90	10	35
		25	

High. Stations of ☿ An. 1702.

	Upmr.	Town.	
	30 25	29 95	30
Jan. 30	25	95	30
	19	83	36
	33	30 02	31
Mar. 12	35	05	30
	32	07	25
	07	29 94	13
Oct. 21	18	99	19
	22	30 00	27

More ſettled Stat. An. 1702.

	Town.	Upmr.	
	30 04	30 13	09
Apr. 27	00	15	15
	02	16	14
	03	16	13
28	01		
	29 99	15	16
	98	15	17
29	93	13	20
	86	06	20
	78	29 89	11
May 13	72	87	15
	74	87	13
	30	68	3
Jun. 10	40	71	31
	44	70	26
	50	70	20
11	51	72	21
	59	70	11
	45	00	41
Aug. 30	57	86	29
	59	88	29
	73	91	18
Sep. 27	72	91	19
	73	91	18
	74	91	17
28	78	95	17
	73	93	20

2.] *A Proſpect of the* Weather, Winds *and* Height *of the* Mercury *in the* Barometer, *on the* firſt Day *of the* Month; *and of the whole* Rain *in every* Month *in the Year* 1703, *and the Beginning of* 1704. *Obſerv'd at* Towneley *in* Lancaſhire, *by* R. Townley, *Eſq*; *and at* Upminſter *in* Eſſex, *by Mr.* W. Derham.

Obſervations *on the* Weather, *&c.* 1703, 1704, *by Mr.* W. Derham. n. 297. p. 1877.

The Mon.	*Weather at* Town.	*Weather at* Upmin.	*Winds at* Town.	*Winds at* Upminſt.	*Barom. at* Town.	*Barom. at* Upm.	*Rain at* Town.	*Rain at* Upm.
Jan.	*Overcaſt*	*Overcaſt*	SE 5	SE 1	29 04 28 91 80	29 39 35 22	15 17	8 89
Feb.	*Overcaſt*	*Froſt and Fair.*	SSE 3	E 1 *Clouds.* S	29 29 37 47	62 68	15 88	6 41
Mar.	*Chequer'd*	*Froſt and fair. Snow.*	WSW NE	NW 1	64 67 73	82 83 92	20 02	4 75
Apr.	*Chequer'd and Cloudy*	*Fair Cloudy Fair*	W	WSW 1 W 4	59 59 55	93 91 91	17 63	12 49
May	*Cloudy*	*Cloudy Thunder, with Hail and Rain.*	NNE	NW *by* N 3 N *by* W 3	49 00 60	66 70 76	17 64	20 77
June	*Cloudy*	*Cloudy Clear*	S	S 0 S 1	38 49 63	61 75 88	24 06	14 55
July	*Cloudy*	*Fair*	SSE.SE E 1	E 1 N *by* E 2	84 80 77	99 96 90	3 65	14 90
Aug	*Cloudy*	*Thunder and Rain Fairer*	SE 1 4 4	N 2 N *by* W 2 *Clouds.* SE	57 55 58	72 72 69	14 21	3 36
Sept.	*Clear Chequer'd*	*Cloudy Fairer*	E	WNW 1 NW 1	80 00 18	30 40 40	32 40	14 86
Oct.	*Chequer'd*	*Fair*	N	NNW 4	28 76 83 86	87 30 08	7 04	9 55
Nov.	*Overcaſt*	*Cloudy*	E	N *by* E 1	29 56 51 52	29 72 69	28 56	7 27
Dec.	*Overcaſt Cloudy*	*Overcaſt Rain*	W 3		36 45 48	 81	10 24	2 14
							196 60	119 94

The

The Mon.	*Weather at* Town.	*Weather at* Upmin.	*Winds at* Town.	*Winds at* Upminſt.	*Barom. at* Town.	*Barom. at* Upm.	*Rain at* Town.	*Rain at* Upm.
			SSE	E 0	80	30 07		
$170\frac{3}{4}$			SE 2	SE *by* E 1	82	10	31 39	4 06
Jan.	*Overcaſt*	*Overcaſt*			85	10		
			W	NW *by* N 1	90	23		
Feb.	*Overcaſt*	*Miſling*			02	26	5 93	2 19
		Cloudy			02	26		
			S	SE *by* E 0	29 11	29 58		
Mar.	*Overcaſt*	*Overcaſt*		SE 1		45	20 78	16 04
		Fairer				40		
	Cloudy	*Rain*	W 4	S *by* W 4	28 72	17		
Apr.	*and*	*with hail*	NW 7	*Clouds*		94	18	
	Chequer'd	*Fair*		SW *by* W		07	38	

From theſe Tables it is to be obſerv'd,

1. That much more Rain falleth at *Towneley* than *Upminſter*.

I have an Extract of the Rain at *Paris* and *Liſle*, as far as the *French* have publiſh'd their Obſervations. And by comparing the Rain of one Place with that of another, I find that there is about twice as much Rain falleth at *Towneley*, as doth either at *Upminſter*, *Paris*, or *Liſle*. Mr. *Townley* hath formerly obſerv'd, that as much more Rain falleth at *Towneley* as *Paris*. And M. *de la Hire* obſerves, that more Rain falleth at *Liſle* than *Paris*. But *Towneley* doth far exceed.

At *Liſle*, one Year with another, the Depth of the Rains amount to 22 Inches 3 Lines, *Paris* Meaſure, or 23 in 3 *l.* which make about $23\frac{1}{2}$ Inches *Engliſh*, or $24\frac{1}{2}$. At *Paris*, one Year with another, they amount to 20 Inches $3\frac{1}{2}$ Lines *Paris* Meaſure, which is near 22 Inches *Engliſh*. But at *Towneley*, one Year with another, according to Mr. *Towneley*'s Computation formerly, the Rains amount to above 41 Inches Depth. And by taking eight other Years, in which the Rain was obſerved both at *Towneley* and *Upminſter* (*viz.* from 1696 to 1704.) I found that all the eight Year's Rain at *Towneley* amounteth to above 1700 *l. Troy*, at *Upminſter* 823 *l.* only. Which ſaid Sums being divided by 8, give 212 *l.* $\frac{1}{2}$, one Year with another, at *Towneley*, and near 103 *l.* at *Upminſter*. Each of which Sums being doubled, and making a Decimal Fraction of the laſt Figure, doth nearly give the Number of Inches, which all the Rain would have riſen to, if the Earth had not ſwallow'd it up, *viz.* $42\frac{1}{2}$ Inches at *Towneley*, and about $20\frac{1}{2}$ Inches at *Upminſter*. Wherefore the Rain at *Upminſter* is leſs than at *Paris*, at *Paris* than at *Liſle*, and at every one of the Places leſs than at *Towneley* by much: The Reaſon

Reaſon of which vaſt Surmount at *Towneley*, is doubtleſs from the Height of the Hills thereabouts, which retard or ſtop the Weſterly Clouds: From which Point the Winds blow more than any other here in *England*. But

2. Notwithſtanding the great Diſproportion of Rain between one Place and another, yet there is a great Agreement between our Barometers; one riſing or falling when the other doth; and that much, or little, as the other doth, altho' not always ſo exactly in the ſame Proportion.

And this is what I find Monſieur *Maraldi* hath obſerv'd, by comparing his Obſervations at *Paris* with mine at *Upminſter*, in the Years 1697 and 1698. Only at *Paris* the ☿ is commonly three or four Lines lower than at *Upminſter*. And ſo it appears to be at *Towneley*, from this and ſome other Tables, *viz.* three or four Tenths of an Inch lower at *Towneley* than at *Upminſter*. Which is an Argument that *Towneley* and *Paris* are ſituated higher above the Surface of the Sea than *Upminſter* (which is nearly in the ſame Level with *London*) is.

3. There is ſome Agreement between the Winds at *Towneley* and *Upminſter*. Which altho' not always exactly in the ſame Point, yet do often tend the ſame way, blowing within a Point or two perhaps of the ſame Courſe; eſpecially when the Wind is ſomewhat ſtrong. Or if the Winds have differ'd, yet the Scudd (as the Seamen call the Current of the Clouds) hath commonly ſhown the Motion of the upper Air to agree thereto.

This doth often happen, tho' not always. And this Monſieur *Maraldi* hath obſerv'd at *Paris* in the aforeſaid Years, *viz.* "That "there are a great many Days, during the different Seaſons of the "Year, where the Winds are the ſame in both Places, [*i. e. Paris* "and *Upminſter.*] When the Wind was the ſame, both in one part "and the other, it was ordinarily pretty ſtrong, and of long "Continuance. And alſo he obſerved that the Winds had changed "alike in both Places. *Vid. Hiſt. de l'Acad. Roy. des Sciences, An.* 1699.

'Tables *of the* Weather, *&c. for* 1705, *by the* ſame. n. 309. p. 2378.

JANUARIUS.				7 . . . 12 . . . 9			
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.	
5	Gelu. Apricum. Nubilum.	N b W o 1	N E	30 14 17 16	79 90 87		
10	Gelu cum Aere craſſo.	W o E b S o		21 22 25	82 93 87		
15	Gelu ſævum & nubilum. Regelat.	W b N 1 S W o		00 29 97 93	74 85 95		
20	Gelu & Dies Apricus.	E 1 E b S 1		30 03 06 13	73 96 82		
25	Nebula. Clarius. Nubilum.	E b S 1 E S E 1		29 79 80 81	92 103 92	0	36
30	Nubilum. Ningit. Nubilum.	N 1 N b E 1	N b E	30 03 02 29 99	87 97 90	1	l. 11

FEBRUARIUS.				7 . . 12 . . . 9			
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.	
5	Pluviæ.	S 2 S E b S 2		28 89 77 78	98 102 93	2	68
10	Apricum. Nebuloſum. Pluvia.	S S E 1 S 5	S W b S	29 85 81 66	97 115 107		
15	Gelu. Apricitas cum tenui nebula.	N b W o		30 39 31	84 88		
20	Nebuloſum. Nubiloſum.	E b N 2		03 29 97 86	92 100 95		
25	Geloſum. Apricum. Pluvioſum.	S b E 1 S 2	S S W	28 27 19	81 115 95		
30				Sum. Pluviæ.		5	l. 53

MARTIUS.

MARTIUS.				6 ... 12 .. 9		
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.
5	Nubilum.	N N E 3	N E	29 61	94	
	Serenum.			65	90	
	Gelu.	S o	W b N	41	86	
10	Apricum.	E N E 1		40	112	
	Nubilum.			40	90	
		E 1	S	24	94	
15	Pluvia.					
				17	105	
20	Caliginoſum cum Imbribus nivoſis.	N b E 2		65	88	
	Clarius, cum	N b W 2		21	83	
25	guttulis nivoſis.			33	104	
				48	81	
	Turbidum	S b W 3		35	116	
30	& pluvioſum.	S W 8		30	127	l.
				22	108	5 55

APRILIS.				5 ... 12 ... 9		
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.
	Nubiloſum.	W S W 1		29 72	102	
5	Turbidum.	S W 5		70	122	
	Guttæ.			66	120	
		E b N 1	S b W	34	98	
10	Pluvioſum.			32	117	
				25	106	
	Gelu cum	N o		82	79	
15	Apricitate.			90	116	
	Nubilum.			96	98	
	Nubiloſum.	W b S 1		91	101	
20		W 2		92	134	
	Placidius.			85	120	
	Pruina. To-	W o	N b W	70	86	
25	nitru cum	1	N b W	80	125	
	Grand. pluv.			87	117	
	Sudum	W b N 1		68	100	
30	&					l.
	Calidum.			73	109	5 15

MAIUS.				5 ... 12 ... 9		
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.
		S W b S 1		29 61	115	
5	Dies nubi-	S b W 2		56	150	
	lofus.			55	120	
	Nubilum.	S S W 1	N W	30 07	104	
10		W b N 2		05	142	
	Apricum.			29 98	124	
	Imbres	N W b N 2		80	9?	
15	Grandinis,					
	& Pluviæ.			95	97	0 22
	Nubilum.	N 1		78	106	
20		N b E 2		78	124	
	Apricum.			80	113	
	Nubilum &	N b E 2	N N E	85	93	
25	Frigidum.	N 2		91	120	
	Clarius.			96	101	
	Nubilum	W b N 1		71	98	
30	&					l.
	Frigidum.			85	99	2 03

JUNIUS.				5 ... 12 .. 9		
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.
	Nubilum	S W 1	W	29 62	119	
5	& Calidum.	N N W 1	W N W	65	143	
	Guttæ.			64	126	
	Apricum	E S E 2		30 03	110	
10	cum Calore.	E b S 2	S E b S	01	153	
	Nubil. Pluv.			29 94	126	0 30
	Nebula.	W b S 1		92	127	
15	Apricitas	2		92	152	
	fervida.			93	132	
	Nubilum.	E 1		95	125	
20	Fervidum.					
	Minus fervid.			94	125	
	Nubilum.	S W b W 2		62	137	
25	Guttæ.	W 3		59	151	
	Imber.			50	131	0 08
	Nebula	N 0		84	106	
30	Apricitas.	W 1		92	156	l.
	fervida.			04	134	3 29

JU-

JULIUS.				5 ... 12 ... 9			
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.	
	Apricum.	W o	N W	30 08	122		
5	Pluvia.	N W 2		08	139		
	Pluvia.			10	116	0	82
	Nubilum.	N b W 3		29 79	112		
10	Imber & mi-	5		88	120		
	nus calidum.			30 80	118		
	Apricum	E b S o		29 96	112		
15	Fervor æſtu-	S 2	N	93	163		
	oſus.			90	145		
	Apricitas	S W b W o		30 03	115		
20	cum fervore.	N N W 2		03	164		
	Nubilum.			03	136		
	Nunc Apri-	W b S o		29 72	110		
25	cum: Nunc	S b W 3	W	69	170		
	Nubilum.			66	148		
	Apricum.	W b S 1		79	116		
30	Nubilum.	S W 2		82	151		l.
	Minus nubil.			82	135	5	56

AUGUSTUS.				5 .. 12 ... 9			
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.	
	Nubilum.	W S W 1	W	29 80	133		
5	Minus Nu-	W b N 1		86	158		
	bilum.			86	148		
	Apricitas.	S S W 3	S W	48	131		
10	Ventoſa.	S W 6		56	158		
	Nebuloſum.			44	138	1	00
	Turbidum.	S W o		97	109		
15	Nubiloſum.	S S W 1		94	153		
				82	132		
	Apricum.	S 1	S W	61	120		
20	Guttæ.						
	Minus nubil.			65	129		
	Apricum.	W 1	N W	34	105		
25	Guttæ.	W N W 6		42	128		
	Minus nubil.			49	117	0	07
	Multa	S 1	S S W	68	127		l.
30	Pluvia.	S b W 4		71	142	10	81
				74	124		

SEPTEMBER.				6 . . . 12 . . 9		
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.
5	Nunc Apri-	S W b W o	W S W	29 88	107	
	cum, nunc	3		88	144	
	Nubilum.			84	118	
10	Nubilum.	S S W o	S W ſup.	77	102	
			N W inf.			
	Imber.			86	108	
15	Nubilum.	W N W o	N b W	30 13	119	
	Nebuloſum.	W 1	N W	15	145	
	Nubilum.			15	129	
20	Nubiloſum.	E 1		25	124	
		E b N 4		25	138	
				22	128	
25	Pluviola.	S W b S 1		29 36	110	
		S S W o		38	122	
				40	113	
30	Pruina &	N W o		48	93	
		W b N 1		50	112	
	Apricitas.			42	92	2 04

OCTOBER.				7 . . . 12 . . . 9		
	Cœlum.	Ventus.	Nubes.	Barom.	Th.	Pluvia.
5	Nunc Im-	S 1		28 93	111	
	bres, unuc	S b W 2		99	127	
	Apricum,			29 10	111	0 56
10	Nebula	S E o		93	101	
	craſſa.	E S E o		98	128	
	Apricum.			30 05	108	
15	Nubiloſum.	W S W 2	W	29 75	98	
	Apricum.			78	108	
20	Apricum.	S E 1		2 18	86	
	Nubilum.	E b S 2	S E b E	16	112	
	Tonitru, &c.	E N E 2		22	108	5 69
25	Apricum	N 2		86	89	
	&	3		92	103	
	Frigidum.			30 04	87	
30	Gelu	N b E 2		29 94	87	
	cum					l.
	Apricitate.			30 00	89	16 01

NOVEMBER.	Cœlum.	Ventus.	Nubes.	8 . . . Barom.	Th.	12 . . . Pluvia.	9
5	Gelu, & Apricitas. Nubilum.	E N E 1 E b N 1	E	29 68 72 72	83 103 101		
10	Nubilum. Pluviosum.	S 2 6		80 44	103 120	0	27
15	Gelosum & Apricum.			30 05	80		
20	Nebula crassa. Pluvia. Turbidum.	N 2 W 1 9		29 57 57 35	89 89 98	0	91
25	Gelu & nebula tenuis.	W 0		65 67 71	79 85 76		
30	Neb. tenuis. Nubilum Pluit.	S b W 2 4	S S W	10 10 28 84	102 112 111	5	84

DECEMBER.	Cœlum.	Ventus.	Nubes.	8 . . . Barom.	Th.	12 . . 9 Pluvia.
5	Nunc Nubilum, nunc Apricum.	W 2 W b N 3	N W	29 10 25 46	92 102 92	
10	Nubilum.	N N W 1		45 61	88 89	
15	Pluviola. Pluit.	S W b W 1 W b S 3		34 36 31	100 101 95	1 21
20	Pluit. Clarius. Gelu.	S 1		28 73 73 76	94 100 84	1 83
25	Nubilum. Pluvia. Nivosa.	N b E 1	N N E	29 72 76 90	94 96 88	0 48
30	Caliginosum.	S E b S 1 S E 1		92 90 86	87 88 85	l. 21 70

In

Explication of the Tables.

In hiſce Tabulis Quintum tantùm diem cujuſque menſis excerpſi; quod commodum Anni dabit conſpectum.

Non multâ explicatione præter Titulum indigent hæ Tabulæ, niſi in Columnis *Ventorum* & *Nubium* (in quibus uſus ſum Notis Anglicanis.) Quippe eorum varietas Romanis non innotuit.

Quatuor Plagæ principales his literis notantur, viz. N. Septentrio: S. Meridies: E. Oriens: W. Occidens.

Plagæ intermediæ harum literarum conjunctione denotantur. E. g. N W. denotat ventum, quem Seneca vocat *Corum*, quem a Solſtitiali occidente flare dicit. S W Africum, qui ab occidente hiberno flat, uti Seneca. S b W denotat plagam illam quæ proximè juxta Meridiem ſita eſt; S S W proximam huic: S W b S huic proximam, ſive quæ ſita eſt inter hanc & Africum: Et ſic de cæteris.

Notæ numerales Ventis adjectæ indicant Ventorum vim. Cyphra [0] notat Aeris tranquillitatem, ſive nullum flare Ventum. [1] Ventum adeo languidum denotat, ut candelam accenſam vix extinguere valeat. [2] fortiorem. [7, 8 ad 12, 15 vel 20] denotant Ventos violentos, & magis bacchantes.

Quoad Columnam *Thermometri*, notandum eſt, *Gelationis* gradum eſſe circa 85. Sed Pruina eveniet circa 90, vel paulo ſupra.

In Columnâ *Pluviarum*, aliquando notavi Pluviæ pondus, quod in diebus pluvioſis (in Tabulâ notatis) decidit. Et in fine cujuſque Menſis Summa Pluviæ totalis iſtius menſis notatur. In toto hoc Anno 84,62 Libræ Pluviæ deciderunt, iſtarum Librarum quas Angli *Troy weight* vocant.

Infundibulum Pluviam recipiens eſt circulare, cujus Diameter 12 pollicibus Anglicanis æqualis eſt.

Denique hæ Obſervationes ter de die factæ fuere, niſi abſens, vel aliter occupatus eſſem. Horæ obſervandi, tum ante, tum poſt Meridiem, in ſummitate cujuſque menſis notantur.

Remarks *on the Weather,* &c.

Circa finem Februarii, & per maximam Martii partem, Noſtrates *Dyſpnœâ*, & *Tuſſi* ubique fere affecti ſunt. Judicent Medici, an hæc proveniant à Ventis orientalibus, unâ cum frigidâ & humidâ cœli temperie, quod tunc frigidum, non autem geloſum fuiſſe, Tabulæ oſtendunt.

Apr. 1. Mane *Parelia* ab aliis viſa ſunt; ſed mihi non contigit videre.

Junius menſis adeo fervidus & ſiccus fuit ut Aquæ defecerint, Fruges languerint, Gramen arefactum fuerit. Droſomelia quoque frequentia fuere. Et Secale ubique uredine tactum.

Aug. 11. Ventus adeo bacchatus eſt, ut perniciosiſſimus arborum fructibus fuerit.

Et quamvis pluvia copioſa ſucceſſit, tamen Stagna arida fuere in Septembre, & magna Graminis inopia.

Dec. 19. Maximus fuit (ut opinor) *Mercurii in Barometro Deſcenſus* hoc mane; ſequenti modo.

$8^h \frac{1}{4}$ mane	28,28 pollices.
10	28,06
11	27,94
$11\frac{1}{2}$	27,94
$12\frac{1}{2}$	28,03
1 p. m.	28,13
1. 10′	18
1. 20′ Ventus W 7	20
2. Ventus W 9	34

Cœli autem Tempeſtatumque mutationes non adeo notabiles, ac Mercurii. Tantùm ventus poſt meridiem vehemens fuit, & noctu multum Pluviæ. Sed audivimus calamitoſiſſimam tempeſtatem Corbili eodem die fuiſſe.

Hic maximus Mercurii deſcenſus ab aliis obſervabatur. In Obſervatorio Grenovicenſi ad 27,80 pollices Mercurius deſcendebat; Cantuariæ urbis ad 27,90.

In ſupputatione Pluviæ penè oblitus ſum profunditatem Pluviæ notare. Si terra non abſorpſiſſet, ad 16,924 pollices Anglicanos fere exſurrexiſſet. Hic Annus ideo pro ſicco habendus eſt. Nam proportio Pluviæ media ſingulis Annis eſt circa $20\frac{1}{2}$ pollices *Upminſtri*; $42\frac{1}{2}$ *Townlei* in Com. *Lancaſtriæ*; & 22 *Pariſiis* in *Gallia*; & 24 pollices in Urbe *Flandriæ* vocatâ *Inſulæ*, uti ſupra obſervavi.

XI. The Society having put into my Hands Dr. *Scheuchzer*'s Obſervations of the Weather, *&c.* made at *Zurich* in the Year 1708, and having receiv'd from Dr. *Mich. Angelo Tilli* the Quantity of Rain which he obſerv'd to fall at *Piſa*; I have compar'd theſe Obſervations with mine made at the ſame time at *Upminſter*; and have put what I could of them into the annexed Tables. In the former of which, I have repreſented Dr. *Scheuchzer*'s and my Barometrical Obſervations: In the latter, his Rain Obſervations, thoſe of Dr. *M. A. Tilly*, and mine own; all reduced to our *Engliſh* Meaſure. But becauſe I am not as yet certain of the true Proportion between the *Tuſcan* and *Engliſh* Weight, I have therefore given Dr. *M. A. Tilly*'s Rain, both in the *Tuſcan* Pounds and Ounces, as he ſent it me; as alſo reduced to our *Engliſh Troy* Pound and Centeſimals of that Pound, according, to Mr. *Greaves*'s Proportion, which is different from that aſſigned by Sir *Jonas Moor*.

Tables *of the* Barometrical *Altitudes for* 1708, *at* Zurich *in* Switzerland; *and of the* Rain *at* Piſa *in* Italy, *and* Zurich, *and* Upminſter, *for* 1707, 1708, *by Mr.* W. Derham. n. 341. p. 342. *With* Remarks *on the Winds, Heat, and Cold*, &c.

As for the *Thermometer*, it would have been in vain to have compared Dr. *Scheuchzer*'s Obſervations with mine, by Reaſon we have not yet a Standard for Thermometers, as we have for the Barometers: they being every where in all, or moſt Reſpects different; ſome with ſmall Bottles of Spirits; ſome accordingly with longer, ſome

Obſervations *with the* Thermometer.

with ſhorter; ſome with wider, ſome with narrower Canes or Shanks; ſome fill'd with more highly rectify'd, and conſequently more expanſive Spirits; ſome with more phlegmatic and duller Spirits.

The Difference particularly between Dr. *Scheuchzer*'s and my Thermometer is, his is about one Foot long; that I obſerv'd with all along ('till it was broken this Year) about two Feet and a half; and that I now obſerve with three Feet and a Quarter; the Bore of the Stalk is ſmall, and the Ball is large, and conſequently the Rang great, anſwering every the leaſt Alteration of Heat and Cold.

But yet, thus much I have been able to obſerve by comparing Dr. *Scheuchzer*'s and my Thermometrical Obſervations, *viz.* That notwithſtanding the *Alpine Snows* have mighty Effects on the Weather in *Switzerland*, and other conterminous Places, yet there is much more Agreement between the Heats and Cold at *Zurich* and *Upminſter*, than before comparing them, I imagin'd. (I ſpeak with relation to laſt Year only, having no other Obſervations.) For in Winter, altho' I imagine we have more warm Days than they; and in Summer, that they have greater Heats than we; yet I obſerve that the Colds and Heats in both Places, begin and end nearly about the ſame Time: And that oftentimes any remarkable Weather (eſpecially if of ſomewhat long Continuance) affecteth one as well as the other Place. Thus, for Inſtance, *June*, which was (ſome part of it at leaſt, particularly the very Day after the Solſtitial-Day, *June* 12.) remarkably Cold in *England*, ſeems to have been not very different at *Zurich*; Dr. *Scheuchzer*'s Thermometer divers Times that Month (tho' not on the very ſame Days perhaps) deſcending as low, or rather lower than in the Month before, yea, as many Days in the Winter Months. I obſerv'd too, that all this Month their cold Weather conſtantly preceded ours here about five or more Days. An Indication that the Weather in both Places was influenced by the ſame Cauſes, whether from the *Alpine* Hills and Cold, or the Influx of the Moon and other heavenly Bodies, or any other Cauſe.

And as in *June* there was a great Agreement in the unuſual Cold, ſo in *Auguſt* there was not much leſs Agreement in Heat; the Heats in both Places being great, and beginning to abate about the ſame Time, only a little ſooner here than there.

In Winter alſo, although I imagine we have a greater Number of warmer Days than they, yet I find that a warm Winter Month there is ſo here; and a cold one there, is a cold one here likewiſe. Thus in *February* and *March*, *October* and *November*, a great Agreement ſeems to have been between the Heats and Colds of both Places, ſome Days excepted. But *January* was at the Beginning not

not ſo conſtantly Cold, for the Seaſon at *Upminſter*, as it ſeems to have been at *Zurich*. And *December* laſt, which from the eighth Day to *Chriſtmas*-Day, was here moderate and open Weather, and after that more intenſely Cold than even in the *Long-froſt*, *Anno* 1683, by the fewer Thermometrical Obſervations which Dr. *Scheuchzer* made then, than in other Months, the greateſt part of that Month ſeems to have been intenſely Cold at *Zurich*, as the latter part thereof was with us remarkably in *England*.

—*of the* Winds.

As to the *Winds*, which I did not enter into Tables, becauſe it may be ſufficient to obſerve in general, that although many Days they agree in both Places, yet there are many more in which they differ. When they do agree, I find it is chiefly when the Winds are ſtrong, and of long continuance; and more, I think, when Northerly and Eaſterly, than in the other Points. Alſo, I have obſerv'd, that a ſtrong Wind in one Place hath been a weak one in the other.

—*of the* Barometrical *Obſervations*.

As to the *Barometrical Obſervations*, I have thought it worth while to ſpecify them. Mine own Obſervations I ſelected, which were made at Noon; and Dr. *Scheuchzer*'s as near Noon as might be. For which reaſon, I commonly took his Morning Obſervations, becauſe made, for the moſt part about ten or eleven a Clock. Alſo I took thoſe made with his bent Barometer; becauſe they ſeem'd to me (eſpecially at the beginning of the Year) to be the moſt accurate.

The Altitudes of this *Mercury* he meaſureth by the *Paris* Foot, which I have reduc'd to our *Engliſh* Meaſure; for which reaſon I have alſo all along noted their Differences.

It is manifeſt from the Tables, that throughout the whole Year, the *Mercury* was lower at *Zurich* than at *Upminſter*, by ſometimes one, ſometimes above two Inches *Engliſh*. The moſt remarkable Difference was at the latter End of *September*, and beginning of *October* when the Difference was for a good while above two Inches *Engliſh*. The reaſon of which, I gueſs, was becauſe at *Zurich*, I imagin'd the Air was more enclin'd to wet, at that Time, than at *Upminſter*; as alſo, becauſe the Winds then were Northerly and Eaſterly with us, which, 'tis well known, do make our Barometers riſe, even in our wet Weather. But the mean Difference between Dr. *Scheuchzer*'s and my Barometers, I take to be about half an Inch *Engliſh*. From whence I conclude, that the Situation of *Zurich* is near a Quarter of an *Engliſh* Mile higher than that of *Upminſter* above the Surface of the Sea; or elſe that that part of the Terraqueous Globe, lying nearer the Line, is (according to the receiv'd Opinion) higher, or farther diſtant from the Center, than ours is, lying nearer the Pole.

It may be obſerv'd from the Barometrical Tables, that (as near the Equinoctial the Barometer is obſerv'd to ſtand nearly at a Stay, but the more Northerly the Latitude, the greater the Rang of the *Mercury*, ſo) at *Zurich*, the Difference laſt Year was not ſo great between the higheſt and loweſt Stations of the ☿, as it was either at *Paris* or *Upminſter*. For at *Zurich*, the Difference was only one Inch *Paris* Meaſure; at *Paris*, Dr. *Scheuchzer* ſaith, 'twas one Inch two Lines and an half; but at *Upminſter* it was eighteen Inches, (and ſome Years it is more) which is greater than either of them.

I obſerve, although there be ſome, and that a pretty deal of Agreement between the riſing and falling of our Barometers, one being very often high or low, when the other is ſo; and one oftentimes riſing or falling when the other doth ſo; and one riſing much or little, or falling much or little when the other doth; yet it is not ſo certainly ſo, as it is nearer home. I have before given a Table of ſome Heights of the *Mercury* obſerv'd at *Upminſter*, and at 200 Miles diſtance in *Lancaſhire* at the ſame time. And in the *Hiſt. de l'Acad. Roy. des Scien. Anno* 1699. Monſieur *Maraldi*, by comparing his Obſervations at the *Paris Obſervatory* with mine at *Upminſter*, takes notice, "That there "is a great Agreement between the Variation of the Heights of the "Barometers in both places; that he finds almoſt always that when one "riſeth or falleth, the other doth ſo too, although not always alike: "That the Days in each Month whereon the *Mercury* hath been high- "eſt or loweſt, it hath been the ſame at *Paris* as at *Upminſter*, but or- "dinarily ſomewhat more than three or four Lines lower at *Paris* than "*Upminſter*". But the Agreement between the Variations of Dr. *Scheuchzer*'s Barometers and mine, although often great, yet is not ſo conſtantly, nor ſo certainly great as nearer home, *viz.* at *London*, *Lancaſhire*, *Paris*, and other places, with which I have made the Compariſon.

—on the Rain. The Rain was obſerv'd at *Piſa* in *Italy*, by Dr. *Mich. Angelo Tilli*; and at *Zurich* in *Switzerland*, by Dr. *J. J. Scheuchzer*, and by my ſelf at *Upminſter* in *Eſſex*.

The Rains for the moſt part are more frequent at *Upminſter*, than either at *Zurich* or *Piſa*; I mean, we have more Rainy Days than they. But yet the Rains in both theſe Places are much greater in Quantity, in the whole Year, and in ſome Months, eſpecially the Autumnal and Winter Months, than our Rains are at *Upminſter*. *May*, *June*, and *July*, and a great part of *Auguſt*, in 1707, ſeem to have been very dry, and I ſuppoſe ſearching Months at *Piſa*, as in ſome meaſure ſome of them were here: And in that Time leſs Rain fell there than here. But the following Autumnal Months made at *Piſa* ſufficient Amends, either by the great Quantity that fell at a Time, I ſuppoſe in Thunder, and ſuch like haſty large Showers;

Showers; or elſe by the Quantity and Frequency of both. What a prodigious Quantity was that, for inſtance, of above 32 Pounds on *Auguſt* 19? (If it all fell on that, and not ſome on the preceding Days). But we find very large Quantities at a time to have fallen on divers Days, where it is manifeſt the Rain was weighed every Day, *viz.* ten Pound, nine Pound, and other large Quantities for ſeveral Days together, in the cooler Autumnal Months. But as the Weather groweth warmer, I imagine their Rains at *Piſa* are fewer; and what falleth, falleth in large Quantities. For which reaſon the quantity of Rain in the Spring Months of *March*, *April*, and *May* 1708, (oftentimes dripping Months in *England*) is nearly the ſame both at *Piſa* and *Upminſter*.

As to the Rain at *Zurich*, I obſerve, that altho' their Rains are leſs frequent than ours in *Eſſex*, yet they ſeem to be more frequent than theirs at *Piſa*: But the Quantity at *Zurich* is greater than at *Upminſter*, and leſs than at *Piſa*.

'Tis Dr. *Scheuchzer*'s Opinion, "That more Rain falleth in *Switzerland* than in *France*; at *Zurich*, than at *Paris*". To confirm which, he giveth us this Table of eight Year's Rain at *Paris*, to which I ſhall add mine for *Upminſter*.

The Rain at Paris *in* 8 *Years.*						*At* Upm.	
The Year.	*Depth in Lines of* Paris *Meaſure.*		*Depth in Inches of* Paris *Meaſure.*		*Depth in* Engliſh *Inches & Centeſ.*	*Depth in* Engliſh *Inches & Centeſim.*	
			Inch	*Lin.*			
1699	224	1/4	18	8 1/4	19 93	15	11
1700	240	1/2	20	1/2	21 37	19	03
1701	256	1/4	21	4 1/4	22 77	18	69
1702	196	1/4	16	4 1/4	17 45	20	38
1703	208	1/4	17	4 1/4	18 51	23	99
1704	238	1/2	19	10 1/2	21 20	15	80
1705	166	3/4	13	10 3/4	14 82	16	93
1706	183	1/2	15	3 1/2	16 31	24	29
Total	*Depth*		142	10 3	152 36	154	22

It is manifeſt from this Table, that the *Zurich* Rain laſt Year (altho' it amounted not to the Quantity which fell at *Piſa* in a whole Year, yet) exceeded both the *Paris* and *Upminſter* Annual Rains of eight Years before. But whether it conſtantly doth ſo or not, will appear from future Obſervations.

I take notice too, that there is a greater Difference between theſe laſt eight Year's Rain at *Paris* and *Upminſter*, than I found in the eight Years, in which I formerly compar'd the Rain of *Towneley*, *Paris*,

Paris, *Liſle* and *Upminſter* together; for by that Compariſon, it appear'd, that leſs Rain fell at *Upminſter*, than at either of the other three Places. But according to theſe later eight Years in the Table, a ſmall Matter more falleth at *Upminſter* than at *Paris*. For the mean Proportion for *Paris* (which according to former Years was above 20 Inches *Paris* Meaſure, or 22 Inches *Engliſh*) is according to theſe laſt eight Years, no more than 17 Inches, 9 Lines *Paris* Meaſure, or 19 Inches *Engliſh*: And *Upminſter* Rain, which I formerly computed at, Year by Year, about 20 Inches and an half *Engliſh*, is for theſe eight Years much the ſame, or a little more than that at *Paris*.

The Proportions therefore which I ſhall now lay down for the yearly Rain of all Places, whoſe Rain I have had Information of, are theſe; for *Zurich* ('till farther Obſervations are made) $32\frac{1}{2}$ Inches; for *Piſa* ('till farther Obſervations) $43\frac{1}{4}$ Inches; for *Paris*, 19 Inches; for *Liſle*, 4 Inches; for *Towneley* in *Lancaſhire*, $42\frac{1}{2}$ Inches; for *Upminſter*, $19\frac{1}{4}$ Inches; all the ſame, that is *Engliſh*, Meaſure.

The laſt Obſervation I make is, the great uſe of Cold to the making of Rain. That Exhalations and Vapours are the Matter of Rain, is not to be doubted; how they are raiſed, I ſhall not enquire; it is ſufficient for my preſent purpoſe to ſay, that when thoſe Vapours are raiſed, they are conſtipated and condenſed into Clouds and Rain, chiefly by the Cold of the Air to which they are elevated. And the greater the Quantity of Vapours raiſed is, and withal the more intenſe the Cold of thoſe airy Regions, the greater is the Quantity of Rain. Now this is manifeſt from the annexed Tables, compar'd with Dr. *Scheuchzer*'s and my Weather, *&c.* Obſervations. Thus for inſtance *January*, which Dr. *Scheuchzer* frequently obſerv'd was ſometimes warm, ſometimes cold, and appeareth farther to have been ſo by his Thermometrical Column, and which was the ſame with us in *South Britain*, that Month, I ſay, had plenty of Rain at *Zurich*, *Upminſter*, and *Piſa* too. The ſame might be ſaid of *February* for *Zurich*, and probably *Piſa* too. So alſo for *December* in 1707, at *Piſa* and *Upminſter*; and *December* laſt at *Zurich* and *Upminſter*. But with us *February* was for the moſt part a cold Month, and the Rain the leſs, by reaſon the Vapours either could not be raiſed in plenty enough, or not be carried high enough, or ſuſpended long enough to be united, but ſoon were precipitated back again to the Earth.

From theſe Cauſes aſſign'd, the plenty of Exhalations and Cold of the airy Regions, I conceiv'd it is, that at *Upminſter*, about the Equinoxes, we have often more Rain than at other Seaſons. But I cannot ſay this is certain and conſtant. Thus it was at the Autumnal Equinox in 1707, not only at *Upminſter*, but at *Piſa* too: So at *Zurich*, *Piſa* and *Upminſter*, about the Vernal in 1708; and at *Zu-*

rich

rich and *Upminſter* the laſt Autumnal Equinox: And this 28*th* of *March* 1709, is a pregnant Proof of this. For, not only unuſual Cold of the Winter hath been ſucceeded by as unuſual Quantities of Rain all this Month, but at this very Time the Weather is open; but withal cool. Particularly *March* 26, many Vapours aroſe, ſo as to fill the Air with a warm ſtinking Fog. The Night following a ſmart Shower of Hail fell, a manifeſt Indication of the Cold of the middle, or Top of the lower Region of the Air. And the Day after, *viz. March* 27, prov'd ſo wet a Day, that almoſt five Pound of Rain fell through my Tunnel, a large Quantity for the Compaſs of 12 Inches Diameter in 14 or 15 Hours Time. The Winds and Clouds were all the while calm and ſtill, and frequently changing from Point to Point, near round the whole Compaſs; and the Rain that fell, fell thick in ſmall Drops. Which makes me think, that the warm foggy Vapours, raiſed in great plenty the Day or two before, as ſoon as they were mounted aloft, met with ſudden extreme Cold of the middle Region, and were thereby haſtily condenſed, and the Air being at the ſame Time very light (the Barometer being then very low) they ſpeedily tumbled down in ſmall and thick Drops of Rain.

And this I take to be the very Caſe of the Vernal and Autumnal Rains, that in Spring, when the Earth and Waters are looſed from the Brumal Conſtipations, the Vapours ariſe in great Plenty. So alſo in Autumn, when the Heats that diſſipated them in Summer, and alſo warmed the ſuperior Regions, are abated, the Vapours raiſed then in great Plenty are ſoon condenſed by the Cold of the ſuperior Regions, and ſo are forc'd down in more plentiful Rains, than at other Seaſons, when either the Vapours are fewer, or Cold of the ſuperior Regions leſs.

For a farther Illuſtration of this, let us caſt an Eye upon *June* laſt, a Month as unſeaſonably Wet, as 'twas unuſually Cold. The Cold thereof I have already taken Notice of; and the wet Weather accompanying it was ſo unſeaſonable to us in *South Britain*, that altho' we had great and welcome Crops of Hay after a great Scarcity the preceding Year, yet we had ſcarcely any good Weather to make it in. So Dr. *Scheuchzer* ſaith it was with them in *Switzerland*, in his Remarks on that Month: *Fuit hic menſis, ut ex pluviâ menſuratâ conſtat, præter modum humidus, & magno quidem Vegetabilibus Hominibuſque damno. Multum computruit Fœnum; Gramina, quæ nondum fuere reſecta, ad nimium venere maturitatis gradum. Vites earumque Floſculi multa ſuſtinuerunt damna a Pluviæ continuo fere lapſu; deciderunt tenella Petala, Foliis rubigo inducta eſt, ut macra admodum ſit Autumni venturi ſpes*, &c.

Having conſider'd the Uſe of Cold to the Production of Rain, I ſhall remark one Thing concerning the *Alps*; and that is, I cannot but

but think that thoſe, and all ſuch like high Mountains, and the Snows they are cover'd with, are of great Uſe to the neighbouring, and more diſtant Countries, in generating their Rain, and performing other great Offices of Nature. From ſome Obſervations I have made in comparing Dr. *Scheuchzer*'s and my own larger Tables, having ſo frequently obſerv'd the Riſing and Fallings of the Barometer, ſome of the moſt conſiderable Variations of the Wind, the moſt remarkable Alterations of Heat and Cold, and of Wet and Dry; I have ſo often obſerv'd many of theſe to precede in one Place what hath follow'd in another, that I am apt to think that even *England* may ſometimes partake of the Effects of the *Alpine Mountains* upon the Air and Vapours. It is certain that their very cold Weather in *December* laſt, and the Relaxation thereof preceded ours: Which makes me inclin'd to think it might probably be deriv'd from them to us. All the former part of that Month, eſpecially from about the 8*th* Day till the 24*th*, was here mild and open. But on *Chriſtmas* Day it began to be colder, and the following Days to freeze harder and harder; inſomuch that on *December* 30, my Thermometer was a great deal lower than ever I had ſeen it before. And two Perſons in *London* told me, that the Spirits in their Thermometers fell ſeveral Degrees lower this laſt Winter, than they had done in the ſelf-ſame Thermometers during all the long and remarkable Froſt in the Year 1683. Whether at *Zurich* the Cold was more exceſſive, than it uſed to be in other Years, Dr. *Scheuchzer* doth not ſay; but he noteth the Air to have been exceſſively Cold, and his Thermometrical Obſervations ſhew it to have been ſo ſome time before, in, and after *Chriſtmas*. And Dr. *Newton*, in a Letter to me from *Florence*, ſays, "The Cold was there ſo great, that "for twenty Years paſt they had not been ſenſible of greater; it "wanting on *Twelfth-day* but half a Degree of the Extremity". Their *Twelfth-day*, I reckon, fell on *December* 26, *O. S.* and conſequently their ſo eminently Freezing Day preceded ours about four Days.

And as their Cold, ſo by Dr. *Scheuchzer*'s Obſervations, I find the Relaxation thereof preceded ours a ſhort Time. For about the latter End of *December*, the Weather appears to have been milder, at leaſt leſs intenſely Cold with them. And ſo was ours at the Beginning of *January*, about as many Days after theirs, as their Cold preceded ours.

Thus I have given one eminent Inſtance of what I found leſſer Examples frequently, as I run over Dr. *Scheuchzer*'s laſt Year's Obſervations. But whether there may be any farther Reaſons for any ſuch Concluſions about the Influences of the *Alpine* Eminences and Colds upon far diſtant Places, future Obſervations will determine. But as to their Influences nearer home, Dr. *Scheuchzer* ſaith, *Alpes fœcun-*

fœcunda mater ſunt, ut Fluminum & Nubium, ita quoque Nivis & Pluviæ. Credibile omnino eſt, loca Mari, Alpibuſque viciniora, plus etiam experiri Pluviæ præ remotioribus aliis.

To theſe Remarks I might add Dr. *Scheuchzer*'s Obſervations of the Occurrences in each Month, of what was curious as to Meteors, the State of Health and Diſeaſes, *&c.* Alſo the Increaſe and Decreaſe of their *Zurich* River, the *Limat*, which (like other Rivers that have their Source in the *Alps*) he puts beyond all Doubt (in my Opinion) to receive greater Increments from the melting of the *Alpine* Snows, than from all the wet proceeding from their Rains. But for them, I refer to his Obſervations at large.

From Dr. *Tilli*'s Table of Rain, compar'd with the other Tables it appears, that although, in the Year before, *June* and other Summer Months were dry, yet laſt *June* was a wet Month at *Piſa*, as well as *Zurich* and *Upminſter*; and ſo likewiſe was it about the Autumnal Equinox: And for the ſame Reaſons I imagine, which I have already mentioned.

As to the Exceſs of the *Piſa* Rain above that of other Places, he attributeth it to the ſame Cauſe, that I did that of *Lancaſhire*, namely, *the Height of the Hills, and the Blowing of the Winds for a long Time for ſome one Quarter.* His Obſervation is this, *Libenter admitto Pluviam noſtram ſemper, vel ut plurimùm veſtram ſuperare, eâ ſane ratione ut —— animadvertiſti; & præcipuè ſi aſpera* Corſica *juga, Autumni tempore, nive citò co-operiantur: Tunc Auſtrales venti diu vigent & Imbres. Aquilonares verò frequentius circa* Florentinos *colles, quàm circa* Piſanam *urbem ſpirare planè conſtat. Eſt enim hæc civitas a Borea circumdata montibus, & pari intervallo circa milliaria quinque diſtat a mari.*

The ſame Account of the Situation of *Piſa*, and the great Quantity of Rain falling there, I remember I had ſome Time ſince from a very ingenious Member of this Society, Mr. *Aſton*, who hath been there.

A Table shewing the Heights of the Mercury in the Barometer *in Englisb Inches and Centesimals of an Ineh, both at* Zurich *in* Switzerland, *and at* Upminster *in* South-Britain, *together with the Differences of those Heights, for the Year* 1708.

	January.			February.			March.		
D. of M.	Zurich *in* Engl. *Inches*	Upmin. *in* Engl. *Inches.*	*Differ. in* Engl. *Inches.*	Zurich *in* Engl. *Inches.*	Upmin. *in* Eng. *Inches.*	*Diff. in* Englisb *Inches.*	Zurich *in* Eng. *Inches.*	Upmin *in* Engl *Inches.*	*Diff. in* Englisb *Inches.*
1	28 1	29 4	1 3	28	29 59	1 59	27 90	29 22	1 32
2				8	52	1 44	28	2[illegible]	1 23
3	17	14	97	17	53	1 36	27 85	4	1 57
4	2[illegible]	43	1 17	17	39	1 22	82	6[illegible]	1 83
5	17	42	1 25	75	37	1 12	28	7[illegible]	1 73
6	1	28	1 27	17	44	1 27	12	44	1 32
7	17	43	1 26	12	35	1 23	6	73	1 67
8	27 99	5	1 6	8	40	1 32	27 81	30 1[illegible]	2 3[illegible]
9	64	28 78	1 14	40	67	1 27	81	29 46	1 65
10	46	50	1 4	15	87	1 72	5	18	1 3[illegible]
11	46	97	1 51	14	30 2	1 88	75	30	1 55
12	99	29 38	1 39	27 90	2	2 12	81	50	1 69
13	73	23	1 50	83	29 67	1 84	85	59	1 74
14	73	11	1 38	28	49	1 9	85	45	1 60
15	27 99	28 99	1	27 82	45	1 2	28 6	37	1 31
16				84	47	1 63	13	47	1 34
17	28 17	29 19	1 2	81	32	1 51	8	52	1 44
18	8	28 89	81	27 95	33	1 38	27 90	33	1 43
19	27 90	29 3	1 13	81	36	1 55	28 6	21	1 15
20	90	15	1 25	28	25	1 25			
21	81	28 80	99	17	8	91	27 85	34	1 49
22	73	95	1 22	38	41	1 3	72	8	1 36
23	99	29 12	1 13	35	48	1 13	72	13	1 41
24	90	20	1 30	17	47	1 30	85	6	1 2
25							81	34	1 53
26				20	25	1 5	75	29	1 54
27	81	57	1 66	15	22	1 7	85	16	1 31
28	81	95	2 14	27 95	28 99	1 4	28 4	38	1 34
29				85	94	1 9	27 90	37	1 47
30							95	6	1 11
31	28 08	76	1 68				28	14	1 14

April.				May.				June.			
D. of M.	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*		Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	
1	28	28 97	0 97	8 0	29 53	1 53		27 95	29 65	1 70	
2	27 95	94	0 99	6	69	1 63		28 6	55	1 49	
3	90	29 28	1 38					27 81	86	2 5	
4	81	53	1 72	8	50	42		83	30 7	2 24	
5	90	45	1 55	0	44	44		35	29 96	2 11	
6	85	65	1 80	8	41	1 33		90	69	1 79	
7	90	65	1 75	6	36	1 10		28 8	52	1 44	
8	28	50	1 50					27 90	50	1 60	
9	00	60	1 60	26	62	1 36		90	56	1 66	
10	27 64	62	1 98	12	63	1 51		28 0	56	1 56	
11	75	77	2 2	0	46	1 46		22 90	58	1 68	
12	72	62	1 90	27 90	66	1 76		28 6	59	1 53	
13	90	80	1 90	81	79	1 98		27 81	36	1 55	
14	28	91	1 91	75	83	2 8		85	49	1 64	
15	6	89	1 83	72	68	1 96		90	60	1 70	
16	8	88	1 80	54	66	2 12		85	47	1 62	
17	27 95	93	1 98					28 3	44	1 41	
18	95	85	1 90	64	44	1 80		27 81	40	1 59	
19	28	89	1 89	72	58	1 86		81	47	1 66	
20	6	88	1 82	90	74	1 84		85	73	1 88	
21	6			28 0	81	1 81					
22	8	30	1 92	0	59	1 59		90	70	1 80	
23	00	29 80	1 80	27 95	54	1 59		97	70	1 73	
24				28 8	67	1 59		85	43	1 58	
25	8	80	1 72	17	80	1 63		96	45	1 49	
26	12	85	1 73	15	86	1 71					
27				27 85	84	1 99		72	81	2 9	
28	6	76	1 70	28 8	81	1 73		73	99	2 26	
29				0	87	1 87		72	98	2 26	
30	00	37	1 37	0	84	1 84		75	80	2 5	
31				27 90	78	1 78					

July.				August.				September.			
D. of M.	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl *Inches.*	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches*	*Dif. in* Engl. *Inches.*		Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	
1	28	29 72	1 72	27 85	30 2	2 17		28 16	29 58	1 52	
2	27 95	92	1 97	81	29 84	2 3		00	54	1 54	
3	97	89	1 92	85	70	1 85		17	50	1 33	
4	95	80	1 85	28 6	72	1 56		8	48	1 40	
5	28	67	1 67	10	67	1 57		27 72	61	1 89	
6	27 75	69	1 94	8	56	1 48					
7	81	72	1 91	0	57	1 57		72	45	1 73	
8	28	69	1 69	27 81	93	2 12		72	49	1 77	
9	8	68	1 60	85	98	2 13					
10	12	80	1 68	90	62	1 72		81	45	1 64	
11	0	84	1 84	95	66	1 71					
12	27 81	90	2 9	28 8	89	1 81		64	67	2 3	
13	93	83	1 90	0	93	1 93		46	48	2 2	
14	28 6	68	1 62	27 85	93	2 8		72	43	1 71	
15				75	84	2 9		85	28 65	0 80	
16				72	80	2 8					
17	27 95	63	1 68	73	55	1 82		72	29 30	1 58	
18	90	77	1 87	72	19	1 47		69	67	1 98	
19	28	76	1 76	90	61	1 71					
20	27 72	84	2 12	95	81	1 86		72	88	2 16	
21	28	66	1 66	72	93	2 21		75	86	2 11	
22	6	50	1 44	181	77	96		75	85	2 10	
23	17	56	1 39	90	93	2 3		75	96	2 21	
24	8	84	1 76	95	53	1 58		81	30 20	2 39	
25	6	73	1 67	28 00	51	1 51		56	17	2 61	
26				00	51	1 51		50	12	2 62	
27	27 95	82	1 87	27 95	52	1 57		64	89	2 25	
28	85	54	1 69	85	63	1 78		81	94	2 13	
29	95	66	1 71	28	51	1 51					
30	85	61	1 76	27 85	62	1 77		72	73	2 1	
31	81	962	2 15	28 6	56	1 50					

October.

	October.			November.			December.		
D. of M.	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*
1	27 72	29 92	2 20	28 22	30 21	1 99	28 26	29 36	1 10
2	69	93	2 24	24	18	1 94	30	45	1 15
3							22	50	83
4							27 99	28 96	0 97
5	72	73	2 1	15	6	1 91	73	92	1 19
6	85	30 5	2 20	08	12	2 4	77	29 11	1 34
7				17	29 86	1 69	85	11	1 26
8	81	29 94	2 13				99	15	1 16
9				22	30 8	1 86	28 15	24	1 9
10	72	86	2 14	17	10	1 93	15	24	1 9
11	64	86	2 22	22	29 78	1 56	08	28	1 20
12	72	30	2 34				27 99	40	1 41
13		6		22	30 10	1 88	90	59	1 69
14	90	29 41	1 51	17	00	1 83	73	83	2 10
15									
16				22	15	1 93			
17	87	79	1 92	26			75	74	1 99
18	28 6	59	1 53				90	77	1 77
19	00	49	1 49	22	29 88	1 66	95	52	1 57
20	27 72	70	1 98				99	60	1 61
21	72	30 00	2 28	22	50	1 28	28 6	61	1 55
22	90	2	2 12				6	50	1 44
23	95	29 76	1 81	27 77	27	1 50	27 99	77	1 78
24	95	74	1 79	90	60	1 70	28 17	28	1 11
25	64	89	2 25	28 17	84	1 67	26	36	1 10
26	85	80	1 95				17	30 14	1 97
27	81	67	1 80				22	28	2 6
28	81	63	1 74						
29	28 00	62	1 64				17	29 83	1 66
30	27 90	80	1 90	26	45	1 19	15	80	1 65
31	28 00	73	1 73					49	1 32

A Table

A Table of the Rain at Piſa *in* Italy, *both in* Tuſcan *and* Engliſh *Troy Weight, which fell through a Tunnel of half a Brace Square, from* May *till the End of* December 1707: *As alſo the Quantity of Rain at* Upminſter *in* Eſſex *at the ſame time, which fell through a round Tunnel of* 12 *inches Diameter, in Pounds Troy, and Centeſimals of a Pound.*

	May.			June.			July.		
D. of M.	Piſa Rain in Tuſcan Weight	Piſa Rain reduced to Eng. W.	Rain at Upminſter.	Rain at Piſa in Tnſcan Weight.	Piſa Rain reduced to Engl. P.	Rain at Upminſter.	Piſa Rain in Tuſcan Weight.	Piſa Rain reduced to Engl. P.	Rain at Upminſter.
	l. oz.	l. dec.	l. dec.	l. oz.	l. dec.	l. dec.	l. oz.	l. dec.	l. dec.
1						0 17			0 1
2						2 90			
3						0 05			0 92
4									0 40
5									0 25
6						0 55	2 0	1 84	
7									
8				5 7	5 12				
9									
10						0 06			
11						0 02			0 60
12									0 12
13									0 3
14									
15						0 29			
16									0 17
17									0 16
18							0 3	0 23	
19									
20									
21									
22	0 9	0 69	2 70						0 94
23			1 26						0 65
24			0 17			0 85			
25						0 42			
26									
27						0 33			0 92
28						0 23			0 20
29			0 56						
30			0 56			0 81			
31	*To. wt.* 0 69		5 25		5 12	6 68		2 7	6 37
	Dep. in Inhc. 0 12		1 05		0 88	1 34		0 25	1 27

	Auguſt			September.			October.		
D. of M.	Piſa *Rain in* Tuſcan *Weight.*	Piſa *Rain reduced to* Eng. *W.*	*Rain at* Upminſter.	*Rain at* Piſa *in* Tuſcan *Weight.*	Piſa *Rain reduced to* Eng. *W.*	*Rain at* Upminſter.	*Rain at* Piſa *in* Tuſcan *Weight*	Piſa *Rain reduced to* Eng. *W.*	*Rain at* Upminſter.
	l. oz.	*l. dec.*	*l. dec.*	*l. oz.*	*l. dec.*	*l. dec.*	*l. oz.*	*l. dec.*	*l. dec.*
1									
2	1 1	1 0	1 90						2 54
3							4 8	3 28	
4			0 76						
5			0 09						0 69
6			3 34			0 51			
7			0 16				7 7	6 96	
8			0 45			0 02			
9			0 81			0 04			
10						1 40	1 9	1 61	
11				0 50	0 38	0 70			
12							2 3	2 06	
13			0 10	0 4	0 31	0 51			
14			0 07	2 11	2 68	0 06			
15							3 10	3 52	
16							1 8	1 62	
17			1 68						
18						0 10			
19	32 5	29 75	0 10			0 87			
20	1 8	1 53	1 02	3 8	3 36				
21				7 9	7 11	1 65			1 62
22				10 0	9 18				
23				3 2	2 91				0 80
24	1 4	1 23		6 10	6 27	2 73			0 26
25						0 85			
26						0 46			
27						2 76			
28				5 10	5 35				0 71
29			0 31			1 84			
30			0 9						
31 *Total.*	33 51		88		37 55	14 50		19 66	6 6
Dep. in Inch.	5 76	2 176			6 45	2 90		3 43	1 32

	November.				December.			
D. of M.	*Rain at* Pisa *in* Tuscan *Weight.*		Pisa *Rain reduced to* Eng. *W.*		*Rain at* Upminster.		Pisa *Rain in* Tuscan *Weight.*	
	l.	*oz.*	*l.*	*dec.*	*l.*	*dec.*	*l.*	*oz.*
1								
2							2	8
3					0	33		
4								
5								
6			1	84				
7								
8							5	4
9	9	4	8	57				
10							2	10
11								
12							2	8
13								
14						53		
15					0			
16							3	10
17					0	32		
18								
19	3	9	3	44				
20							5	6
21					0	86		
22								
23	9	5	8	64				
24	0	6	0	46	3	08		
25	2	4	2	14				
26					0	28	3	2
27	1	5	1	30			7	3
28								
29					0	50	7	5
30								
31	*Tot. Wt*		24	55	5	90		
	Dep. in Incb.		4	22	1	18		

	December.	
	Pisa *Rain reduced to* Eng. *W.*	*Rain at* Upminster.
	l. *dec.*	*l.* *dec.*
1		
2	2 45	0 44
3		0 65
4		
5		
6		0 63
7		0 25
8	4 89	
9		0 84
10	2 60	
11		
12	2 45	1 67
13		
14		
15		1 24
16	3 52	0 96
17		
18		
19		
20	5 05	0 82
21		1 38
22		0 22
23		0 25
24		
25		0 16
26	2 91	
27	6 65	0 62
28		1 98
29	6 80	
30		0 03
31	37 32	12 14
	6 39	2 428

A Table of the Rain at Zurich *in* Switzerland, *at* Piſa, *and* Upminſter, *in the Year* 1708. *All reduced to the Depth in* Engliſh *Inches, and Centeſimals of an Inch.*

	January.						February.					
D. of M.	Rain at Zurich		Rain at Piſa.		Piſa Ra. reduced.	Rain at Upmin.	Rain at Zurich.		Rain at Piſa.		Piſa Ra reduc'd.	Rain at Upmin.
	Inches.		l.	oz.	l. dec.	l. dec.	Inches.		l.	oz.	l. dec.	l. dec.
1			5	8	5 20							
2	1						2	½	3	3	2 98	
3												
4			7	2	6 58	0 97	1	¾				
5	1					0 29		¾	0	10	0 76	
6						0 7	2					0 2
7												
8							2					
9			6	3	5 74	0 53			2	4	2 14	
10						2 48			1	8	1 53	
11						1 26						
12							2	½	0	9	0 69	
13						1 91						
14			3	4	3 6	1 88						
15	4					0 4		½				0 18
16						0 92						
17			5	6	5 5		1	¾				
18			2	9	2 52	1 26						
19							4	½				
20	1	½						⅙	2	1	1 90	0 54
21	1											0 51
22	4					0 91						
23	2								7	2	6 58	0 64
24	2		3	6	3 21							
25	1	½				1 7						0 19
26						0 80						
27			4	1	3 75							
28										9	2 52	0
29		½						½				22
30												
31			2	5	2 22							
Tot.	18	½			37 33	14 39	18	⅔			19 10	2 30
Dep.	1	64			6 41	2 878	1	65			3 28	0 46

	March.				April.			
D. of M.	*Rain at* Zurich.	*Rain at* Piſa.	Piſa *Ra. reduced.*	*Rain at* Upmin.	*Rain at* Zurich.	*Rain at* Piſa.	Piſa *Ra. reduced.*	*Rain at* Upmin.
	Inches.	*l.* *oz.*	*l.* *dec.*	*l.* *dec.*	*Lines.*	*l.* *oz.*	*l.* *dec.*	*l.* *dec.*
1	2 3/4				9 3/4			1 16
2						2 10	1 68	0 16
3					7 3/4	2 4	2 14	
4						0 9	0 69	
5								1 54
6				1 27				
7					1			
8					3			
9								0 16
10				0 38	1 1/2			0 24
11				0 37	3/4			
12	3 1/2							0 85
13		8 1	7 40					
14				0 37	1/2			
15	1/2							
16					4 3/4			
17					5 1/2	0 10	0 76	
18		6 3	5 74		3 1/4			
19	2 3/4			0 25		2 2	1 99	
20				0 8	5			
21				0 20				
22				1 37				
23	2 1/8			1 06	6			
24				1 37	1/2			
25				1 43	3 1/4			
26	1/4				1/2			
27				1 29				
28				0 15				
29				0 54				0 65
30	1 1/12							0 01
31	3 1/2	2 6	2 29					
Tot	17 1/8		15 43	10 13	52 3/4		7 26	4 77
Dep	1 51		2 65	2 3	4 69		1 25	0 96

May.

May.								June.							
D. of M.	Rain at Zurich.		Rain at Pisa.		Pisa Rain reduced.		Rain at Upm.	Rain at Zurich.		Rain at Pisa.		Pisa Rain reduced.		Rain at Upm.	
	Lines.		l.	oz.	l.	dec.	l. dec.	Lines.		l.	oz.	l.	dec.	l.	dec.
1								1	1/2						
2										4	1	3	75	0	66
3							1 09	21	3/4	2	2	1	99		
4			5	1	4	66									
5							0 27	2	1/2	3	4	3	06		
6			4	4	3	98				2	8	2	45		
7			3	10	3	52	3 28							0	60
8							0 82	1	3/4	3	3	2	98	0	20
9							0 11							0	90
10										0	9	0	69	0	11
11															
12	1	1/4												1	66
13							0 32		1/2					0	15
14		1/3								2	1	2	68	0	76
15	2	1/3					1 11	3	3/4	0	10	0	76		
16							0 82								
17		1/2					0 01							0	01
18							0 96			11	1	10	17	0	93
19	5	3/4												0	04
20	3	1/4						19							
21							0 53							2	66
22							0 79	1							
23														1	23
24								6	1/4					0	80
25			3	4	3	06								0	44
26								1	1/4					0	38
27	2	1/4													
28									1/3						
29	1														
30			2	10	2	06		6	3/4					0	08
31	4	1/2	1	8	1	53									
Tot	21	1/2			19	35	10 11	66	1/2			28	53	11	61
Dep	1	91			3	33	2 02	5	91			4	90	2	32

July.						August.				
D. of M.	Rain at Zurich.				Rain at Upm.	Rain at Zurich	Rain at Pisa.		Pisa Rain reduced.	Rain at Upm.
	Lines.				l. dec.	Lines.	l. oz.		l. dec.	l. dec.
1	1				0 06					
2										
3	2	1/2								
4					0 03					
5										
6	25	1/2								
7										3 38
8					0 93					
9					0 49					
10					0 59					
11					0 47					0 07
12					0 01					
13					0 11					
14							10	1	9 25	
15					1 00		1	8	1 53	
16					0 16					
17							2	8	2 45	1 05
18	3					3	3/4			0 56
19										
20	2	2/3								
21					0 01					
22										
23						27	3/4			
24					0 01					0 15
25					0 41	1	1/4			0 76
26		3/4								
27										0 31
28		3/4			1 20					
29		1/2				2	1/2			1 32
30	3				0 04		1/4			
31										7 10
Tot	39	1/2			5 52	35	1/2		13 23	14 70
Dep	3	50			1 11	3	15		2 27	2 94

	September.							October.							
D. of M.	*Rain at* Zurich.		*Rain at* Pisa.		Pisa *Rain reduced.*		*Rain at* Upm.	*Rain at* Zurich.		*Rain at* Pisa.		Pisa *Rain reduced.*		*Rain at* Upm.	
	Lines.		*l.*	*oz.*	*l.*	*dec.*	*l.* *dec.*	*Lines.*		*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*
1			1	2	1	07				5	1	4	67		
2														0	03
3			10	0	91	8	0 74								
4							0 06								
5														0	08
6							0 64								
7	2		12	2	11	17									
8	7	$\frac{3}{4}$					0 40								
9	4	$\frac{1}{4}$								4	4	3	98		
10							0 05								
11							0 01	4	$\frac{1}{4}$	14	5	13	13		
12							1 41							0	06
13														0	37
14	5	$\frac{3}{4}$					1 24							0	16
15	2	$\frac{3}{4}$	2	8	2	45	1 10			2	3	2	06		
16															
17															
18	7	$\frac{3}{4}$					0 29			2	6	2	29	0	31
19										1	9	1	61		
20															
21			10	4	9	48		13	$\frac{1}{2}$						
22															
23							0 27							0	02
24			9	4	8	57									
25															
26								6	$\frac{3}{4}$	3	7	3	29		
27	3	$\frac{3}{4}$													
28														0	06
29							0 99								
30							0 08								
31								2	$\frac{3}{4}$					0	05
Tot	34				11	92	7 28	27	$\frac{1}{2}$			31	03	1	14
Dep	3	02			7	21	1 46	2	44			5	33	0	23

	November.				December.			
D. of M.	Rain at Zurich.	Rain at Pisa.	Pisa Rain reduced.	Rain at Upm.	Rain at Zurich.			Rain at Upm.
	Lines.	l. oz.	l. dec.	l. dec.	Lines.			l. dec.
1		3 3	2 98					0 10
2								
3								0 61
4				0 92				0 08
5					17 ½			0 27
6								
7								
8								0 30
9		2 0	1 84					0 66
10								
11				2 22				
12	¾	3 6	3 21	0 26				
13					8			
14								
15								
16								
17								0 54
18								
19								1 84
20								
21								1 22
22								
23	6 ¾							4 00
24								0 22
25								
26								
27								
28								
29								
30				0 90				
31					3 ½ ½			
Tot	7		8 03	4 30	29 ½			9 84
Dep	0 62		0 13	0 86	2 62			1 97

A Proſpect of all the Rain *in the foregoing Tables, in every Month, Half Year, and the whole Year, from* June 1. *N. S. or* May 21. *O. S.* 1707. *to the End of the Year* 1708.

	Depth of the Piſa *Rain.* Engl. *Inches.*	*Depth of the* Upm. *Rain.* Engl. *Inches.*	*Depth of the* Zurich *Rain.* Engl. *Inches.*
May.	0 12	1 05	
June.	0 88	1 34	
July.	0 36	1 27	
Auguſt.	5 76	2 18	
September.	6 45	2 90	
October.	3 43	1 33	
November.	4 22	1 18	
The Half Year's Rain.	21 22	11 25	
December.	6 39	2 43	
Anno 1708.			
January.	6 41	2 88	1 64
February.	3 28	0 46	1 65
March.	2 65	2 03	1 51
April.	1 25	0 96	4 69
May.	3 33	2 02	1 91
The Half Year's Rain.	23 31	10 78	
Depth of the whole Year's Rain.	44 53	22 03	
June.	4 90	2 32	5 91
The Half Year's Rain.		10 67	17 31
July.		1 11	3 50
Auguſt.	2 27	2 94	3 15
September.	7 21	1 46	3 02
October.	5 33	0 23	2 44
November.	0 13	0 86	0 62
December.		1 97	2 62
The Half Year's Rain.	19 84	8 57	15 35
The whole Year's Rain.		19 24	32 66

An Account of the Rain *at* Upminſter *for* 18 *Years, by Mr.* W. Derham. n. 341. p. 130.

XI. The laſt Year (1714) having been ſo remarkably dry, that the Ponds hereabouts are for the moſt Part dry, and the Springs generally either very low or quite failing, I made an Extract (out of my Regiſters of the Weather, *&c.*) of the *Quantity of Rain* which fell at *Upminſter* the laſt 18 Years. The Particulars of which, every Year, may be ſeen in the Table. In one Column of which, the Weight of the Rain in Pounds *Troy*, and Centeſimals of Pounds, may be ſeen; in the other, the Depth of it in Inches and Centeſimals of Inches, or what Height it would have been, had it not been imbib'd by the Earth, or leſſen'd by Exhalations, but been ſuffer'd to have ſtagnated on the Ground.

A TABLE of Rain which fell at *Upminſter*, from the Year 1697, to the Year 1714.

Year.	Weight.		Depth.	
	l.	Cent.	Inch.	Cent.
1697	77	60	15	52
1698	122	32	24	46
1699	75	54	15	11
1700	95	13	19	03
1701	93	45	18	69
1702	101	89	20	38
1703	119	94	23	99
1704	79	02	15	81
1705	84	62	16	93
1706	121	43	24	29
1707	81	55	16	31
1708	96	09	19	22
1709	132	82	26	56
1710	91	84	18	37
1711	118	02	23	60
1712	118	78	23	76
1713	115	80	23	16
1714	55	95	11	19

Remarks on the Dry Year 1704.

Among the *Dry Years*, 1704 was complain'd of for one; which I remember the News-Papers reported to have been ſo conſiderable at *Venice*, that they were forc'd to fetch their Water in Barks five Leagues off, as far as the *Brenta*; ſo that publick Prayers were put up for Rain. Yet we may obſerve, that ſeveral other Years were drier than that with us at *Upminſter*. But among them all, none comparable to the laſt Year 1714. In which the whole Quantity of Rain was no more than 55 *l.* 95 Hundredths, or 11 Inches 19 Hundredths; whereas the leaſt Quantity of any of the preceding 18 Years, exceeded 15 Inches in Depth.

What Effects this Drought hath had in the Bodies of Animals, I leave others to judge. It is well known how contagious and fatal a Diſtemper hath raged among, not only our own black Cattle, but in many other Parts of *Europe*. And I obſerved the *Itch* was Epidemical among the poorer Sort, at the Beginning of the Year; that the *Meaſles* were very common ſome Parts of the Year; and that *Pleuriſies* and *Malignant Fevers* infeſted a great many, eſpecially in the Summer Months. But how far theſe Diſtempers might be owing to the dry Seaſon, I leave to the Phyſicians.

To

To compare with theſe, we have collected out of the *Memoirs* of the *Royal Academy* of *Sciences*, the Quantity of *Rain* and diſſolved *Snow* which has fallen at the *Obſervatory* at *Paris* for 23 Years together; according to the accurate Obſervation of M. *De la Hire*, and have reduced the *French* Meaſure to our own. But it is to be obſerved, that the Diverſity of *Stile* makes the Years not exactly the ſame, though, as to this Matter, the Difference may ſeem very inconſiderable.

The Rain at Paris *for* 23 *Years.*

	French.		*Engliſh*	
Anno	Inch	Lin.	Inch	Cent.
1689	18	11 1/2	20	23
1690	23	3 3/4	24	87
1691	14	5 1/4	15	40
1692	22	7 1/2	24	14
1693	22	8	24	18
1694	19	9	21	07
1695	19	7 3/4	20	96
1696	19	5 1/2	20	76
1697	20	3	21	68
1698	21	9	23	20
1699	18	8 1/4	19	93
1700	20	0 1/2	21	38
1701	21	4 1/4	22	78
1702	16	4	17	42
1703	17	4 1/4	18	51
1704	19	10 1/2	21	20
1705	13	10 1/4	14	82
1706	15	3 5/8	16	32
1707	17	11	19	11
1708	18	3 1/2	19	51
1709	21	9 1/8	23	21
1710	15	8 3/4	17	10
1711	25	2	26	84

XIII. Upon *Tueſday*, the 16*th* Day of *July* 1706, about Eight of the Clock in the Morning, it began to rain in and about *Denbigh*, which continued inceſſantly for 30 Hours, but not very violently, till about Three or Four a Clock in the Morning upon *Wedneſday*, when it rain'd ſomewhat faſter, attended with a terrible Noiſe (like Thunder) with ſome Flaſhes of Lightning, and a boiſterous Wind. About Break of Day the Rain and Wind began to abate of their Violence, which leſſen'd gradually every Hour, till about One or Two a Clock in the Afternoon, and then it perfectly ceaſed, and the Air became clear and ſomewhat calm.

A Storm of Rain at Denbigh *in* Wales, *by* — n. 308. p. 2348.

Upon *Tueſday* the Wind blew South Weſt; but on *Wedneſday* it was come to the North Weſt.

The Effects of this great Storm were diſmal, for it occaſion'd the overflowing of all the Rivers in *Denbighſhire*, *Flintſhire* and *Merionethſhire*, &c. which ſpoil'd a great deal of Corn, and took off all the Hay that was mowed, near the Banks of the Rivers, which was

carried by the Stream in ſuch vaſt Quantities down to the Bridges that it choak'd the Arches and Inlets, inſomuch that it broke down above a Dozen great Bridges. Great Oaks and other large Trees were unrooted and ſwept away, with ſeveral Quickſet Hedges; and ſome Quillets by the Side of the River *Elwy*, ſo covered with Stones and Gravel, that the Owners can't well tell whereabouts their Hedges and Landmarks ſtood; and the ſame River has alter'd its Courſe in ſome Places, ſo as to rob the Landlords on one Side of ſome Acres, and beſtowed as much on the oppoſite Side. Two or three Rivulets, that convey'd Water to ſome Mills, have been ſo choak'd up with Stones and Gravel, that the Owners don't think the Profit will countervail the great Charge of clearing them.

It is affirmed by many, that the great Floods were not ſo much the Effects of the Rain, as the breaking out of an infinite Number of Springs, in ſuch Places, as they were never known to flow from before. In the Town of *Denbigh* a great many broke out in the Houſes and Stables, eſpecially in that Part which lies next the Caſtle on the North Side of it; ſome of which broke out with a great deal of Violence, and in ſuch a Quantiiy, that it is affirmed by ſeveral Men of the Town, that three of theſe new Springs, which flowed out of the Stables of three Inns, were ſufficient to turn any Corn Mill.

At a ſmall Diſtance, Northward of *Denbigh*, lies *Park-Snodiog*, a Rocky Hill, out of which broke out a great many Springs, which flowed ſo plentifully for nine or ten Days, that the Cattle water'd in them for that Time; whereas before and after, the People were forc'd to water them all Summer long at a Well in the Highway, at ſome Diſtance from this *Park-Snodiog*. There are ſeveral deep Holes and Trenches cut in the Highways adjoining to the River *Elwy*, *&c.* ſome ſo very large, as to hide three or four Horſes, which is not attributed ſo much to the overflowing of the River, as to the breaking out of Springs in thoſe very Places.

In *Comb* Mountain there is a Pit of a circular Form, which in the Summer time uſed to have little or no Water in it, and in Winter, as much Water as would ſwell the Surface to about fourteen or ſixteen Yards croſs over: But now in the midſt of Summer it roſe up at leaſt a Yard and a half higher than it was ever known to do in the wetteſt Winters; and overflowing its Banks, it fell down the Hill with ſuch Violence, as to penetrate into the very Body of a Rocky Road, and dug Pits in it, that will bury the biggeſt Horſes; and the Road, which was a common Highway, is now become irreparable.

In

XIV. 1.] In the Month of *March* 1701, in the Forenoon, between the Hours of 10 and 11, I obſerved a remarkable *Water Spout* in the *Downs*. It bore N by E off our Ship, about two Leagues diſtance by Eſtimation; the Wind at E N E. a Top-ſail Gale, and very cold. The Horizon was intirely open and ſerene, except the Northern parts thereof from N N W to N E by E. or thereabouts. The higheſt part of the Cloud appear'd to make an Angle of 45 Deg. of Elevation. About one half of the Cloud, (*viz.* the upper) was very white, and the other extreamly black. The Spout itſelf, (which hung from the lower Part of the whitiſh Cloud) hovered up and down for about 20 Minutes, and during two or three Minutes of the Time, that Part of the Sea exactly under the Spout, did ſparkle up Water to a conſiderable height. The ſparkling run along to the Leeward, (the Cone of the Spout moving that way, and making, it ſeems, a diſcharge, tho' not viſible to us in its Fall) and continued running along for ſix Ships length. Afterwards the Body of the Spout did quickly contract itſelf, and then diſappear'd. About two Hours afterwards the Heavens were intirely overcaſt, and during that Afternoon there fell abundance of Hail, and both Wind and Cold increaſed. I have ſeen ſeveral Water-ſpouts in the *Mediterranean* ſome Years ago, and thoſe uſually during the Time of a ſtark Calm and hot Summer Weather; but to ſee one in our Northern Climate at this Time of the Year, and during Weather both Cold and Windy, is, I think, a little unuſual.

A Water-Spout *obſerv'd in the* Downs, *by Mr.* P. Gordon, n. 270. p. 805.

2.] The 27th of *Auguſt* 1701. being upon the Coaſt of *Barbary*, to the Northward of the Town of *Bona*, upwards of 10 Leagues diſtance at Sea, about 7 a-Clock at Night, ſoon after Sun-ſetting, there appeared in the N E. (which was directly up the Gulf of *Lyons* from us) great and continued Flaſhes of Lightning one after another, with ſcarce any Intermiſſion, and this without Thunder continued till the next Morning; the Flaſhes of Lightning ſometimes repreſenting the ſudden Appearance of a Star, and at other times of a Flaming Sword, and again of a Silver Cord ſtretched along the Clouds, or as the irregular Crack of a Wall from top to bottom.

Spouts *in the* Mediterranean, *by Dr.* A Stuart. n. 277. p 1077.

About eight next Morning we had Thundring, with a Continuation of Lightning of the kind and Appearance abovementioned, all from the N E. or thereabouts.

About nine the ſame Morning, fell down from the Clouds (which look'd diſmally black, lowering, and, as it were, heavy with Rain) in the ſaid N E. quarter, three Water-ſpouts, that in the middle being the greateſt, ſeem'd as big as the Maſt of a Ship, and I judg'd it to be at leaſt a League and a half diſtant from us; ſo that in itſelf, no doubt, it was bigger than three Maſts. The o-

ther two were not by half ſo big. All of them black, as the Cloud from whence they fell; all of them ſmooth, without any Knot or Irregularity; only at firſt falling, ſome fell perpendicularly down, and ſome obliquely, and all of them ſmaller at the lower end than above, giving the repreſentation of a Sword; ſometimes alſo one of 'em would bow itſelf, and again become ſtraight, and alſo ſometimes became ſmaller, and again increaſed its Bulk; ſometimes it would diſappear, and immediately fall down again; ſometimes it became extenuated to the ſmallneſs of a Rope, and again became groſs as before.

There was always a great boiling and flying up of the Water of the Sea, as in a *Jette d'eau*, or Water-work; or this riſing of the Water had the appearance of a ſmoaking Chimney in a calm Day. Some Yards above the Surface of the Sea the Water ſtood as a Column or Pillar, and then ſpread itſelf, and was diſſipated as Smoak: And the Sword-like Spout from the Clouds either came down to the very middle of this Pillar, and as it had been joined with it, as the greateſt, which fell perpendicularly down, ſtill did from beginning to end: Or elſe it pointed to this Column of Water, at ſome diſtance, either in a perpendicular or oblique Line, as the other two leſſer.

There were three or four Spouts more, which appear'd at the ſame time in the ſame Quarter of the Heavens, but neither for Bulk or Duration like theſe three: Thoſe appear'd or diſappear'd ſeveral times, during the Continuance of theſe three.

It was hardly diſtinguiſhable whether the Sword-like Spout fell firſt down from the Cloud, or the Pillar of Water roſe firſt from the Sea, both appearing oppoſite to one another all of the ſudden, as in the twinkling of an Eye. Only I obſerved of one, that the Water boiled up from the Sea to a great height, without the leaſt appearance of a Spout pointing to it either perpendicularly or obliquely, and here the Water of the Sea never came together in the form of a Pillar or a Column, but did fly up ſcatteredly, the Sea being in a boiling Rage round the Place. The Wind being then N E. the ſaid boiling advanced towards the S W. as a flitting or moving Buſh upon the Surface of the Sea, and at laſt ceaſed. This proves that the boiling or flying up of the Water of the Sea may begin before the Spout from the Cloud appears to us: And indeed if there be any ſmall Matter of Priority betwixt theſe two Appearances, the boiling or throwing up of the Sea-water has it: Which begins firſt to boil, and then frames it ſelf into a Pillar of Water, eſpecially on the lower part thereof.

It was obſervable of all them, but more perceptible of the great one; that towards the end it began to appear like a hollow Canal, only black in the Borders, but white in the Middle; and though at firſt it was altogether black and opaque, yet now one could very diſtinctly

ſtinctly perceive the Sea Water to fly up along the middle of this Canal, as Smoak up a Chimney, and that with great Swiftneſs, and very perceptible Motion: And then ſoon after the Spout or Canal brake in the middle, and diſappear'd by little and little: The boiling up, and the Pillar-like form of the Sea-Water continuing ſtill the laſt, even for ſome conſiderable Time after the Spout diſappear'd, and perhaps till the Spout appear'd again, which it commonly did in the ſame Place as before, breaking and forming itſelf again ſeveral times in a quarter of an Hour, or half an Hours time.

The middle one of the three, exceeded all the reſt in Bigneſs, Perpendicularity, Conſtancy of Form and Situation, as well as Duration; but at laſt vaniſhed.

I know not, if any has accounted for this *Phænomenon*, but I imagine it may be ſolv'd by Suction (improperly ſo call'd) or rather Pulſion, as in the application of a Cupping-glaſs to the Fleſh, the Air being firſt voided by the kindled Flax.

It was further obſervable, that the oblique Spouts pointed always from the Wind; that is, that the Wind being at N E. the oblique Spouts always pointed to the S W. tho' at the ſame Time and Moment there were others perpendicular, which remained ſtill ſo, notwithſtanding the Wind.

Alſo that ſuch as were curved had ſtill the Convex ſide from the Wind, and the Concave towards it; that is, the Wind being at N E. the Concave was towards the N E. and the Convex towards the S W.

It rained a great deal during the Continuance of theſe Spouts, and after their total Diſappearance we had half an Hours violent Gale of Wind from the N E. with very little Rain, the Weather afterwards clear'd up.

The Explication of the Tables.

A The Spout of a black Colour, falling out of a black Cloud perpendicularly. *Fig.* 10.

B The Water of the Sea, riſing in the Form of a Pillar or Column in the Middle, and ſcatter'd round about the ſaid middle Column, in form of Smoak, or rather like the falling of a *Jette d'eau*. Theſe two meet one another directly, and the Column of Water from the Sea is commonly groſſer than the Spout from the Clouds.

A A curved Spout, joining with the riſing Water of the Sea at B. *Fig.* 11.

A Repreſents a black Spout, falling obliquely from the Clouds of the ſame Colour. *Fig.* 12.

B Repreſents the aſcending Column of the Sea Water as in *Fig.* 10. with this difference, that here the Spout and Column of Water meet not.

E and W in this Fig. ſignify Eaſt and Weſt. *Fig.* 13.

Fig. 13. 1 2 3 Repreſent the ſucceſſive Progreſſion of the boiling of the Sea from Eaſt to Weſt, or from N E. to S W. and that without any Appearance of a Spout from the Clouds, pointing to either of theſe places.

Fig. 14. A Repreſents the big perpendicular Spout a little before its breaking, white in the middle.

B The Column of Sea Water joining therewith.

2 2 2 2 The Water of the Sea, aſcending in the Form of Smoak up a Chimney, all along the Column at B to the Clouds.

Fig. 15. A The breaking of a perpendicular Spout, commonly beginning in the Middle at A.

B The Riſe of the Sea Water, which begins to fall, and the middle Column to diſappear.

Fig. 16. A An oblique Spout, which after reaching to the Sea in a curved Line, or obtuſe Angle, does ſoon after break at A, and diſappear.

B The riſing of the Sea Water alſo beginning to ceaſe.

Fig. 17. A A perpendicular Spout beginning to fall.

B The beginning Aſcent of the Water of the Sea under it.

Fig. 18. A An oblique Spout beginning, or darting itſelf out of the Clouds.

B The riſing or boiling of the Water, anſwering to it in an oblique Line.

Theſe ſometimes reach down to the Sea or riſing Water, and ſometimes they do not reach thither, but continue a while, as here repreſented.

A Water-Spout at Hatfield *in* Yorkſhire, *by Mr.* Abr. de la Pryme. n. 281. p. 1248.

3.] On the 15*th* of *Aug.* 1687. About two in the Afternoon, appeared a *Spout* in the Air at *Hatfield* in *Yorkſhire*; it was about a Mile off coming directly to the Place where I was; I took my Proſpective Glaſſes to obſerve it as well as I could.

The Seaſon was very dry, the Weather extreme hot, and the Air very cloudy, the Wind aloft, and pretty ſtrong, and (which is remarkable) blowing out of ſeveral Quarters at the ſame Time, and filling the Air hereabouts with mighty thick and black Clouds, layer upon layer; the Wind thus blowing ſoon created a great *Vortex*, Gyration, and Whirling amongſt the Clouds; the Centre of which every now and then dropt down in the Shape of a thick long black Pipe, commonly call'd a Spout; in which I could diſtinctly view a Motion like that of a Screw, continually drawing upwards, and ſcrewing up (as it were) whatever it touch'd. In its Progreſs it mov'd ſlowly over a Hedge-Row and Grove of young Trees, which it made to bend like Hazle Wands, in a circular Motion; then going forward to a great Barn it twitch'd off in a Minute all the Thatch, and fill'd the whole Air therewith. Coming

to

to a very great Oak Tree, it made it bend like the foregoing Trees, and broke one of the greateſt and ſtrongeſt Branches, that would not yield to its Fury, and twiſting it about, flung it a very conſiderable Diſtance off; then coming to the Place where I ſtood, within 300 Yards of me, I beheld this odd *Phænomenon*, and found that it proceeded from nothing but a Gyration of the Clouds by contrary Winds meeting in a Point or Centre; and, where the greateſt Condenſation and Gravitation was, falling down into a Pipe or great Tube (ſomething like the *Cochlea Archimedis*) and that in its working or whirling Motion, either ſucks up Water, or deſtroys Ships, *&c.* having travell'd about a Quarter of a Mile farther, it diſſolv'd by the Prevalency of the Wind that came out of the Eaſt.

4.] I have ſeen another Spout in the ſame Place, which very much confirms me in my Notion of the Origin and Nature of them. The Weather here in this Part of the Countrey, hath been exceeding wet and cool, inſomuch that it ſeem'd rather to be Spring than Midſummer; yet the 21*ſt* of *June* 1702 was pretty warm; on the Afternoon of which Day, about two of the Clock, no Wind ſtirring below, tho' it was ſomewhat great in the Air, the Clouds begun to be mightily agitated and driven together; whereupon they became very black, and were (moſt viſibly) hurried round, from whence proceeded a moſt audible whirling Noiſe, like that commonly heard in a Mill. After a while, a long Tube or Spout came down from the Centre of the congregated Clouds, in which was a ſwift ſpiral Motion like that of a Screw, or the *Cochlea Archimedis*, when it is in Motion, by which ſpiral Nature and ſwift turning, Water aſcends up into the one as well as into the other. It travell'd ſlowly from Weſt to North Eaſt, broke down a great Oak-Tree or two, frighted ſome out of the Fields, and made others lie down flat upon their Bellies, to ſave being whirl'd about and kill'd by it, as they ſaw many Jackdaws to be that were ſuddenly catch'd up, carried out of Sight, and then caſt a great way amongſt the Corn; at laſt it paſs'd over the Town of *Hatfield*, to the great Terror of the Inhabitants, filling the whole Air with the Thatch that it pluck'd off from ſome of the Houſes; then touching upon a Corner of the Church, it tore up ſeveral Sheets of Lead, and roll'd them ſtrangely together; ſoon after which, it diſſolved and vaniſhed without doing any further Miſchief.

— *another, by the* ſame. n. 284. p. 1331.

By all the Obſervations that I could make of this, and the former, I found that had they been at Sea, and joyn'd to the Surface thereof, they would have carried a vaſt Quantity of Water up into the Clouds, and the Tubes would then have become much more ſtrong and opake than they were, and have continued much longer.

It

It is commonly ſaid that at Sea the Water collects and bubbles up a Foot or two high under theſe Spouts before that they be joyned: But the Miſtake lies in the Pellucidity and Fineneſs of thoſe Pipes, which do moſt certainly touch the Surface of the Sea before that any conſiderable Motion be made in it, and that when the Pipe begins to fill with Water, it then becomes opake and viſible.

As for the Reaſon of their diſſolving of themſelves after that they have drunk up a great Quantity of Water, I take it to be through the great Quantity of the Water that they have carried up, which muſt needs thicken the Clouds, and impede their Motion, and by that Means diſſolve the Pipes.

A Fall *of Water from a* Spout *in* Lancaſhire, *by Dr.* R. Richardſon. n. 363. p. 1097.

5.] We have frequent Accounts of Damage done at Sea by Spouts of Water, yet ſuch rarely happening at Land, induc'd me to take the following Relation of a remarkable one, which fell on *Emott-more*, nigh *Coln* in *Lancaſhire*, on *Tueſday* the *3d* of *June* 1718, about Ten in the Morning; when ſeveral Perſons, who were employ'd in digging *Peat* nigh the Place where this Accident happen'd, upon a ſudden were ſo terrified with an unuſual Noiſe in the Air, that they left their Work and ran Home, which was about a Mile from the Place: But to their great Surprize, they were intercepted by Water; for a ſmall Brook in the Way was riſen above ſix Foot perpendicular in a few Minutes Time, and had overflown the Bridge.

It is to be obſerv'd, that there was no Rain at that Time on *Emott-more*, only a Miſt, which is very frequent upon thoſe high Mountains in Summer-time. There was a great Darkneſs in the Place where the Water fell, without either Thunder or Lightning. (as I had my Information from an Eye-witneſs.) The Meadows at *Wicolae* were ſo much floated, that the like had not been ſeen in ſeveral Years before, tho' there it was a very bright Day.

I went to view the Place where the Water fell; tho' I believ'd this Inundation might proceed from an Eruption of Water out of the Side of the Mountain; ſuch being not unfrequent, where Lead or Coal have been dug, but neither have ever been ſought for here. The Ground was torn up to the very Rock, where the Water fell, which was above ſeven Foot deep, and a deep Gulf made for above half a Mile, and vaſt Heaps of Earth caſt up on each Side of it, ſome Pieces remaining yet above twenty Foot over, and ſix or ſeven Foot thick. About ten Acres of Ground were deſtroyed by this Flood. The firſt Breach where the Water fell is about ſixty Foot over, and no Appearance of any Eruption, the Ground being firm about it, and no Cavity appearing. The Ground too on each Side the Gulf was ſo ſhaken, that large *Chaſmes* appear'd at above thirty Foot Diſtance.

On

Fig. 1.

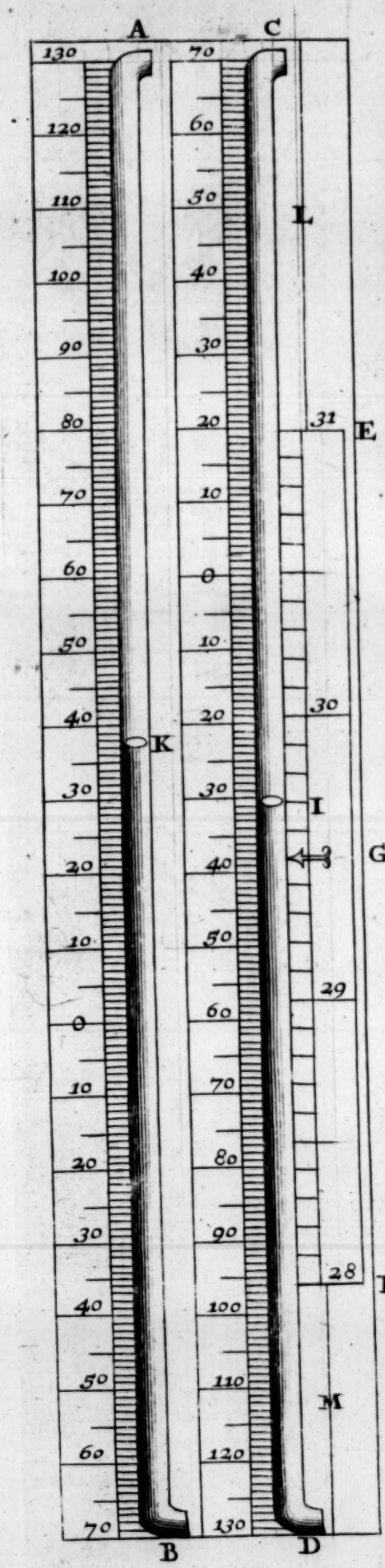


Fig. 2.

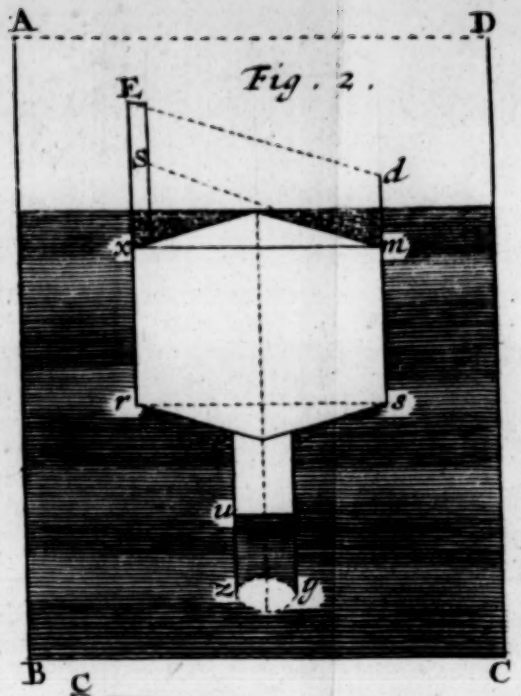


Fig. 4.

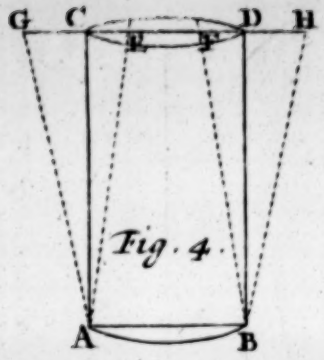
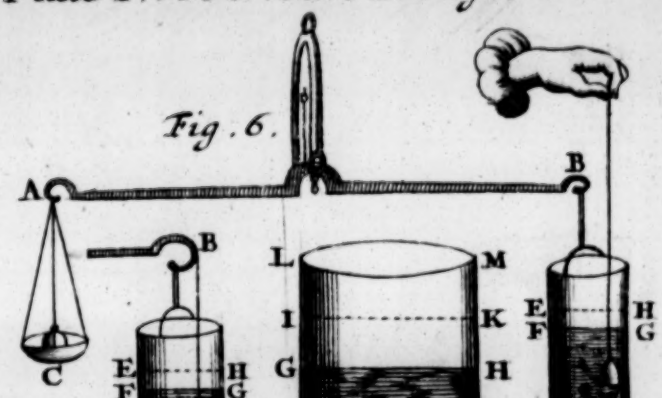


Fig. 6.



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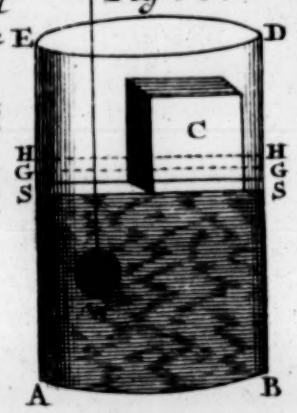

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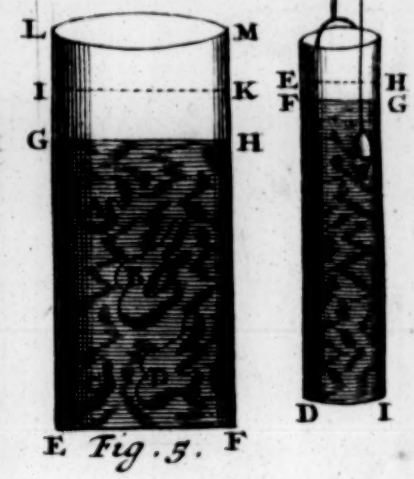

Fig. 18.

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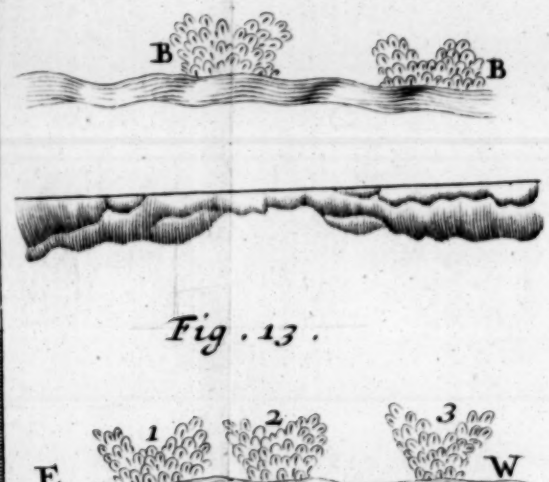

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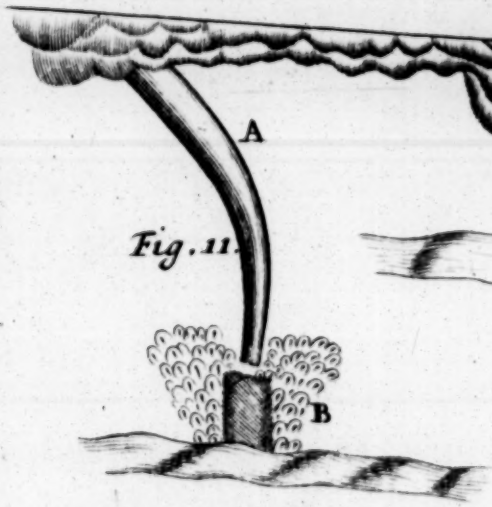

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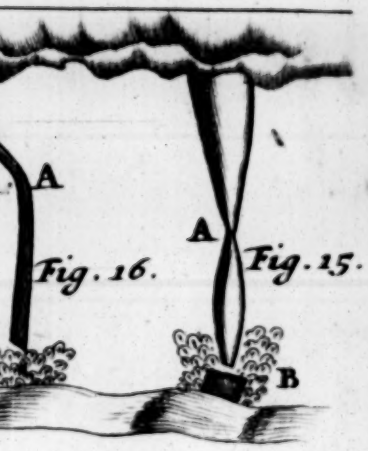

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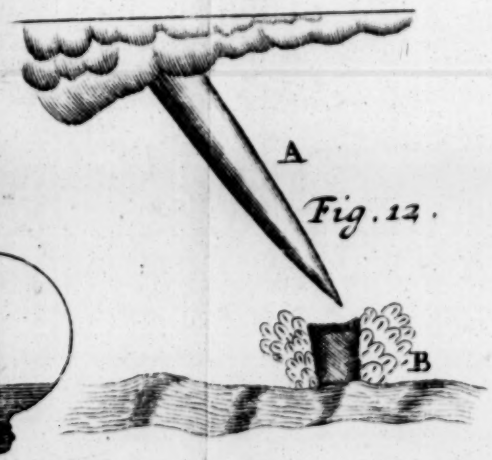

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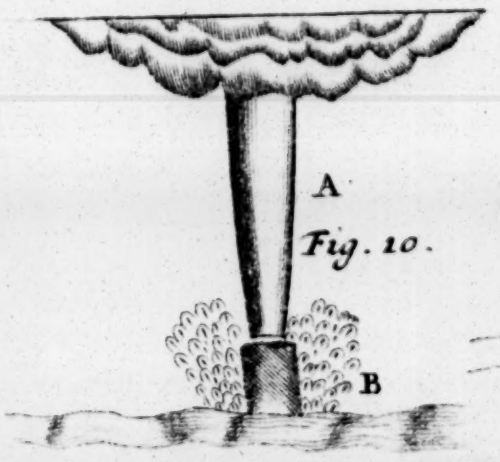

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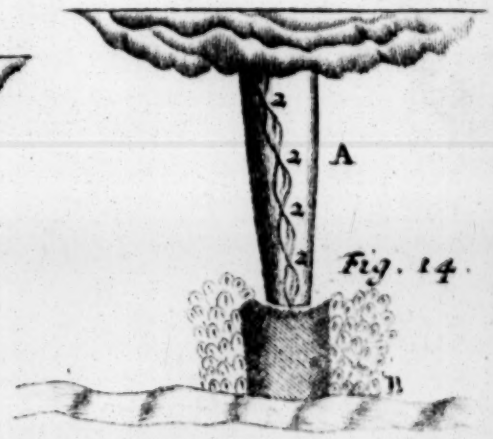

It is commonly ſaid that at Sea the Water collects and bubbles up a Foot or two high under theſe Spouts before that they be joyned: But the Miſtake lies in the Pellucidity and Fineneſs of thoſe Pipes, which do moſt certainly touch the Surface of the Sea before that any conſiderable Motion be made in it, and that when the Pipe begins to fill with Water, it then becomes opake and viſible.

As for the Reaſon of their diſſolving of themſelves after that they have drunk up a great Quantity of Water, I take it to be through the great Quantity of the Water that they have carried up, which muſt needs thicken the Clouds, and impede their Motion, and by that Means diſſolve the Pipes.

A Fall *of Water from a* Spout *in* Lancaſhire, *by Dr.* R. Richardſon. n. 363. p. 1097.

5.] We have frequent Accounts of Damage done at Sea by Spouts of Water, yet ſuch rarely happening at Land, induc'd me to take the following Relation of a remarkable one, which fell on *Emott-more*, nigh *Coln* in *Lancaſhire*, on *Tueſday* the 3*d* of *June* 1718, about Ten in the Morning; when ſeveral Perſons, who were employ'd in digging *Peat* nigh the Place where this Accident happen'd, upon a ſudden were ſo terrified with an unuſual Noiſe in the Air, that they left their Work and ran Home, which was about a Mile from the Place: But to their great Surprize, they were intercepted by Water; for a ſmall Brook in the Way was riſen above ſix Foot perpendicular in a few Minutes Time, and had overflown the Bridge.

It is to be obſerv'd, that there was no Rain at that Time on *Emott-more*, only a Miſt, which is very frequent upon thoſe high Mountains in Summer-time. There was a great Darkneſs in the Place where the Water fell, without either Thunder or Lightning. (as I had my Information from an Eye-witneſs.) The Meadows at *Wicolae* were ſo much floated, that the like had not been ſeen in ſeveral Years before, tho' there it was a very bright Day.

I went to view the Place where the Water fell; tho' I believ'd this Inundation might proceed from an Eruption of Water out of the Side of the Mountain; ſuch being not unfrequent, where Lead or Coal have been dug, but neither have ever been ſought for here. The Ground was torn up to the very Rock, where the Water fell, which was above ſeven Foot deep, and a deep Gulf made for above half a Mile, and vaſt Heaps of Earth caſt up on each Side of it, ſome Pieces remaining yet above twenty Foot over, and ſix or ſeven Foot thick. About ten Acres of Ground were deſtroyed by this Flood. The firſt Breach where the Water fell is about ſixty Foot over, and no Appearance of any Eruption, the Ground being firm about it, and no Cavity appearing. The Ground too on each Side the Gulf was ſo ſhaken, that large *Chaſmes* appear'd at above thirty Foot Diſtance.

On

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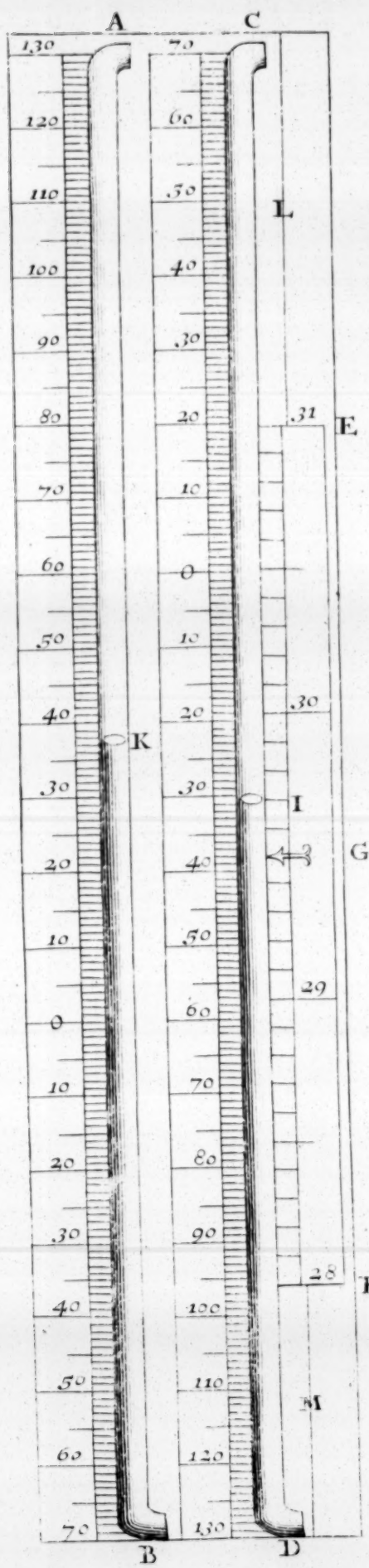

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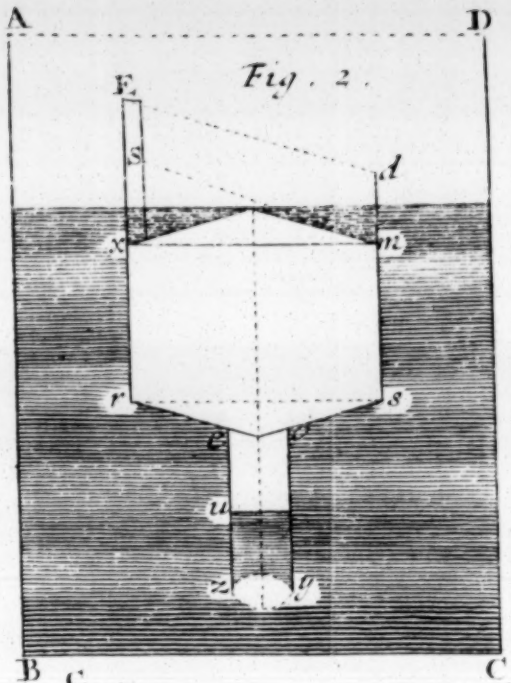

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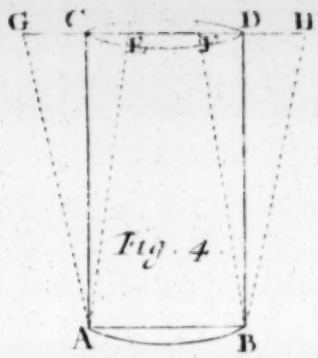

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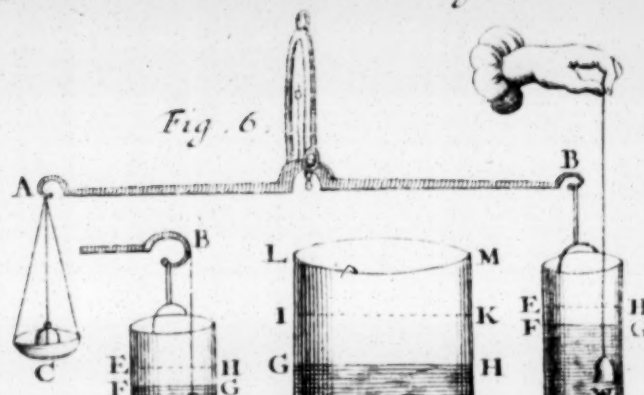

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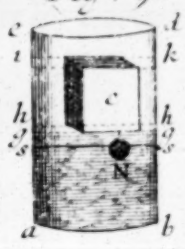

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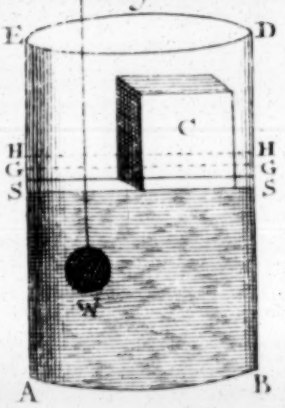

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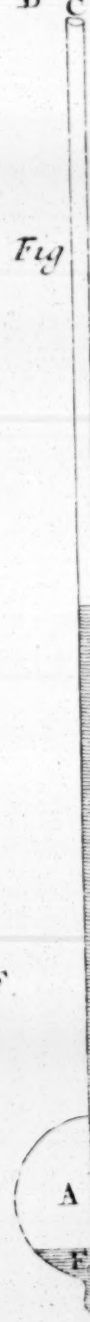

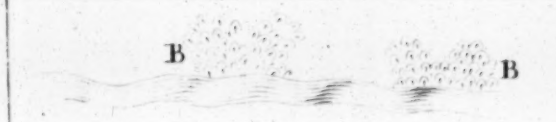

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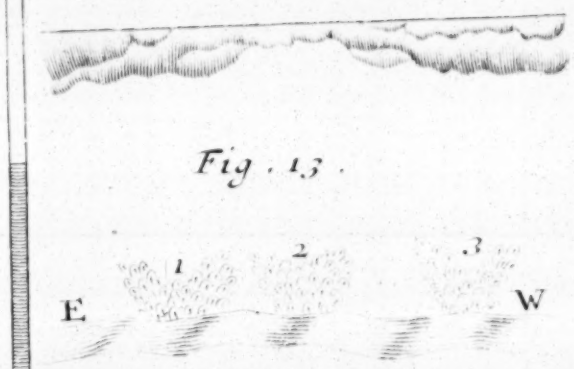

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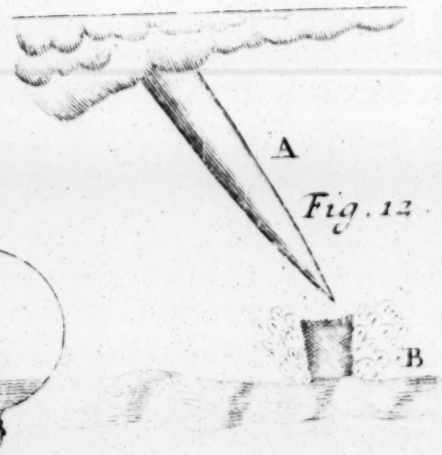

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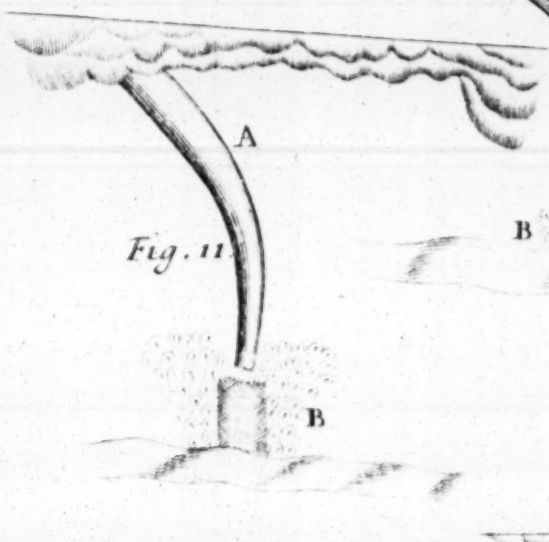

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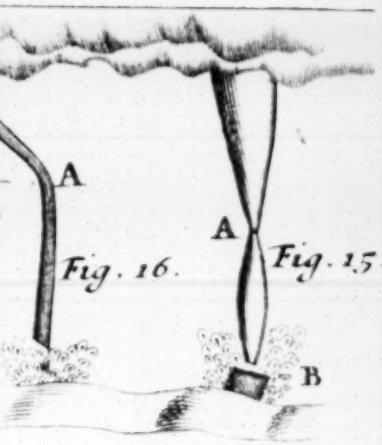

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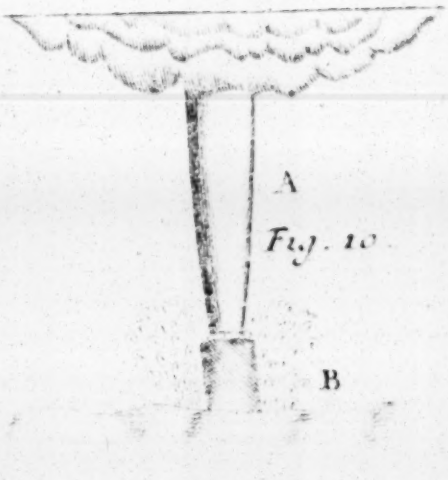

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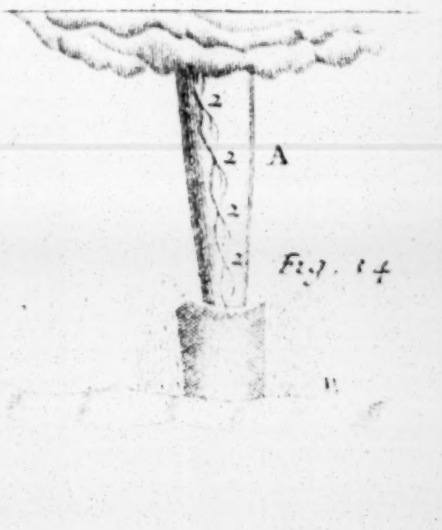

XV. On the *7th* of *June* 1711, there happened a very great Storm of Hail, accompanied with terrible Thunder and Lightning. It begun about *Rotherham* (a little beyond which was ſomething of a Hurricane) where it burnt a noted Tree. About One of the Clock it reached *Wentworth-Woodhouſe*. The Hail-ſtones were from 3 to 5 Inches in Circumference, and ſome ſay larger, which killed ſeveral Pidgeons; but the chief Damage done here was in the Glaſs-Windows. In *Waſh* Field, about two Miles from thence, it did vaſt Damage. Some part of the Field eſcaped, and the *Barley* received no Damage; but the Generality of the *Wheat* was cut off, about half a Yard from the Ground, and the *Rye* about two Foot. The Stubble, tho' green at firſt, turn'd white, that it look'd like a Field newly ſhorn. The *Rye* was afterwards mown, inſtead of ſhearing, and yielded not above a Buſhel of Corn in a Wain-load. Some of the *Wheat* took Root, and grew up. The Breadth of this Storm was about half a Mile, as appear'd by the Effects. In Places adjoyning there was no Hail, but large Drops of Rain. A Joyner meaſured one of the Hail-ſtones with his Compaſſes, and it was an Inch and half in Length; but theſe were not Globular, but moſtly Oblong. The Generality of them at *Bolton-upon-Dearne* were of the Bigneſs of Cherries; tho' one was taken up that was an Inch and half in Diameter and round, not long, and ſomewhat flat, as the others were. Great Quantities of Twigs and ſmall Boughs were beaten off the Trees.

A Storm of Hail *in* Yorkſhire, *by Mr.* R. Thoreſby. n. 335. p. 514.

XVI. 1.] Having receiv'd from Mr. *Townley*, an Account of the State of the Atmoſphere in *Lancaſhire*, during the late great Storm, I ſhall compare his Obſervations with mine at *Upminſter*: I ſhall not give a long Hiſtory of the Devaſtations, *&c.* but ſhall make a few Remarks of a more Philoſophical Conſideration.

Obſervations *on the* Great Storm, *Nov.* 26. 1703. *by Mr.* W. Derham. n. 289. p. 1530.

To look back then to the preceding Seaſons of the Year, *April*, *May*, *June* and *July* were wet Months in our Southern Parts. In *April* there fell 12, 49 *l.* of Rain thro' my Tunnel. (And about 6, 7, 8 or 9 *l.* I eſteem a moderate Quantity for *Upminſter.*) *In* May *there fell more than in any Month of any Year ſince the Year* 1696, viz. 20, 77 l. *June* likewiſe was a dripping Month, in which fell 14, 55 *l.* And *July*, altho' it had conſiderable Intermiſſions, yet had 14, 19 *l.* Above 11 *l.* of which fell on *July* 28*th* and 29*th* in violent Showers; and I remember the News Papers gave Account of great Rains that Month from divers Places of *Europe*; but the *North of England* (which alſo eſcaped the Violence of the late Storm) was not ſo remarkably wet in any of thoſe Months; at leaſt not in that great Proportion more than we, as uſually they are; as I gueſs from the Tables of Rain, which I had from Mr. *Towneley*: Particularly *July*

was a dry Month with them, there being no more than 3,65*l.* of Rain fell through Mr. *Towneley*'s Tunnel of the ſame Diameter with mine.

September was a wet Month, eſpecially the latter Part of it; there fell of Rain in that Month 14,86*l.*

October and *November*, tho' not remarkably wet, yet have been open warm Months for the moſt Part. My Thermometer (whoſe freezing Point is about 84) hath been very ſeldom below 100 all this Winter, and eſpecially in *November*.

I have given this Account of the preceding Diſpoſition of the Year, particularly as to Wet and Warmth, becauſe I am of Opinion, that theſe had a great Influence in the late Storm; not only in cauſing a Repletion of Vapours in the Atmoſphere, but alſo in raiſing ſuch Nitro-ſulphureous or other heterogeneous Matter, which, when mix'd together might make a ſort of Exploſion (like fir'd Gunpowder) in the Atmoſphere. And from this Exploſion, I judge thoſe Coruſcations or Flaſhes in the Storm to have proceeded, which moſt People, as well as myſelf, obſerved, and which ſome took for Lightning.

On *Thurſday*, *Nov.* 25. in the Morning was a little Rain, the Winds high in the Afternoon S. b. E. and S. In the Evening there was Lightning, and between Nine and Ten of the Clock at Night a violent but ſhort Storm of Wind and much Rain at *Upminſter*, and of Hail in ſome other Places. There fell in that Storm 1,65*l.* of Rain. The next Morning, *Friday Nov.* 26. the Wind was S. S. W. and high all Day, and ſo continued. About 12 at Night the Storm awaken'd me, which gradually increas'd till near Three that Morning. And from thence till Seven it continued in the greateſt Exceſs; and then began ſlowly to abate, and the *Mercury* to riſe ſwiftly. The Barometer I found at 12 h. $\frac{1}{2}$ P. M. at 28,72, where it continued till about 6 the next Morning, or $6\frac{1}{4}$, and then haſtily roſe; ſo that it was got to 82 about 8 of Clock, as in the Table.

How the Wind ſate during the late Storm, I cannot poſitively ſay, it being exceſſively dark all the while, and my Vane was blown down. But by Information from ſome that were forc'd to venture Abroad, and by my own Gueſs, I imagine it to have blown about S. W. by S. or nearer to the S. in the Beginning, and to veer about towards the Weſt towards the End of the Storm, as far as W. S. W.

The Degrees of the Wind's Strength being not meaſurable, but by gueſs, I thus determine, with Reſpect to other Storms. On *Feb.* 7. $169\frac{8}{9}$ was a terrible Storm that did much Damage. This I number 10 Degrees; the Wind then W. N. W. Another remarkable Storm was *Feb.* 3. $170\frac{1}{2}$, at which Time was the greateſt Deſcent of the ☿ ever known. This I number nine Degrees. But this laſt of *November*, I number at leaſt 15 Degrees.

As

As to *November* 17*th* (whereon Mr. *Townley* mentions a violent Storm in *Oxfordſhire*) it was a ſtormy Afternoon here at *Upminſter*, accompany'd with Rain, but not violent, nor ☿ very low. *November* the 11*th* and 12*th* had both higher Winds and more Rain; and the ☿ was thoſe Days lower than even in the laſt Storm of *November* 26*th*.

I have had Accounts of the Violence of the Storm at *Norwich*, *Beccles*, *Sudbury*, *Colcheſter*, *Rochford*, and ſeveral other intermediate Places.

A Table, ſhewing the Height of the *Mercury* in the Barometer, at *Towneley* and *Upminſter*, before, in, and after the Storm.

Townelev.			*Upminſter.*		
Day.	Hour.	Height of ☿	Day.	Hour.	Height of ☿
Novr.	7	28 98	Novr.	8	29 50
25	3	64	25	12	39
	9½	61		9	14
	7	80		8	33
26	3	70	26	12	28
	9½	47		9	10
	7	50		12½	28 72
27	3	81		7½	82
	9½	95	27	12	29 31
	7	29 34		9	42
28	3	62		8	65
	9	84	28	12	83
				9	20 07
29	7	88	29	8	25

I have receiv'd an Account from a Clergyman at *Lewes* in *Suſſex*, not only that the Storm made great Deſolations thereabouts, but "That a Phyſician travelling ſoon after the Storm to *Tiſehyrſt*, a-"bout 20 Miles from *Lewes*, and as far from the Sea, as he "rode pluck'd ſome Tops of Hedges, and chewing them, found "them ſalt. Some at *Lewes* hearing this, taſted ſome Grapes that "were ſtill on the Vines, and they alſo had the ſame Reliſh. The "Graſs on the *Downs* in his Pariſh was ſo ſalt, that the Sheep in "the Morning would not feed till Hunger compell'd them, and "afterwards drank like Fiſhes, as the Shepherds report. This he "attributeth to Saline Particles driven from the Sea. —— He

" heareth alſo, that People about *Portſmouth* were much annoyed with " ſulphureous Fumes, complaining they were almoſt ſuffocated there- " with.

—*on the* ſame *in* Suſſex, *by* J. Fuller *Eſq*; ibid.

2.] We live ten Miles off the Sea in a direct Line, and yet can ſcarce perſuade the Country People, but that the Sea Water was blown thus far, or that during the Tempeſt the Rain was ſalt, for all the Twigs of the Trees the Day after were white, and taſted very ſalt; as I am inform'd almoſt by every Body, though I did not taſte them time enough myſelf, nor obſerve it, and that not only upon this Hill where we live facing the Sea, but in all other Places within 14 or 15 Miles of the Sea, as well in the Vallies, between which and the Sea are ſeveral high Hills, as on the Hills themſelves.

— *on the* ſame *by Mr.* Lewenhoek, *ibid.*

3.] On the 8*th* of *December* 1703, we had a dreadful Storm from the South-Weſt, inſomuch that the Water mingled with ſmall Particles of Chalk and Stone, was ſo daſh'd againſt the Glaſs-windows, that many of them were darken'd therewith.

The lower Windows of my Houſe, notwithſtanding that they look to the North Eaſt, and ſo ſtood from the Wind, were ſo cover'd with the Particles of the Water, which the Whirlwind caſt againſt them, that in leſs than half an Hour's time they loſt moſt of their Tranſparency. Suppoſing this might be Sea-water, I view'd theſe Particles with my Microſcope, and found they had the Figure of our common Salt: As to the upper Windows, where the Rain had beat againſt them, there was little or no Salt to be found ſticking upon them.

During the ſaid Storm, and about eight of the Clock in the Morning, I caſt my Eye on my Barometer, and obſerv'd that I had never ſeen the *Mercury* ſo low; but half an Hour after the *Mercury* began to riſe, though the Storm was not at all abated, at leaſt to any Appearance; from whence I concluded the Storm would not laſt long, which accordingly ſo happen'd.

Some think that the ſcattering of this Salt Water will do a great deal of harm to the Fruits of the Earth; but I am of Opinion that a little Salt ſpread over the Surface of the Earth, eſpecially where it is heavy Clay-ground, does render it Fruitful; and ſo it would be if the Sand out of the Sea were made uſe of to the ſame Purpoſe.

——*on the* ſame, *by the* ſame, n. 295. p. 1793.

4.] From the Waves of the Sea, which the Winds had carried over our Meadows and Orchards, I preſaged a fruitful Year. Since that ſeveral Perſons concern'd in Tillage and Grazing have aſſured me, that they never knew ſuch a plentiful Year for Graſs, as alſo for Peaſe and Beans, as the laſt Summer was.

XVII. The

XVII. The Society having put into my Hands ſome Papers relating to the late *great Froſt*, and having myſelf receiv'd Accounts thereof from my Friends at home and abroad, I ſhall endeavour to give an Account of the *Degree* and *Effects* of this remarkable *Froſt*.

The Hiſtory *of the* great Froſt, 1708, *by Mr.* W. Derham. n. 324. p 454.

As to the *Degree* of this Froſt, I believe it was greater (if not more univerſal alſo) than any within the Memory of Man. The greateſt that hath happen'd within our Memory, was the *Long Froſt* in 1683; but the late Froſt, although of ſhorter Continuance, was more intenſe than that. My Thermometer was lower on *December* 30. (†) than it had ever been ſince 1697, when I firſt began my Thermometrical Obſervations: The ſelf-ſame Thermometer in our Repoſitory in *Greſham*-College was lower than ever it was before: [The Particulars of its greateſt Deſcents are theſe; *January* 26. 1696. 41 *Gr. January* 5. 1683. 40 *Gr.* and *January* 3. 1708-09. 43 *Gr.*] And laſtly, that in another ſelf-ſame Glaſs in *London*, [Mr. *J. Patrick*'s] the Spirits were four or five Degrees lower than in 1683.

The Degree of the Froſt in England.

(†) *Vid.* Supra. S. XI.

In *London* the greateſt Contraction of the Spirits was on *January* 3. which was an exceſſive cold Day at *Upminſter* alſo: But the far greateſt Contraction with us was on *December* 30. before. The reaſon of the Difference is, becauſe my Thermometer is always abroad in the open Air, where no Sun-ſhine toucheth; but thoſe two *London-Glaſſes* are within Doors, in Rooms where no Fires are made. And it is eaſy to obſerve, that the Froſt doth not preſently exert its greateſt Force, nor ſo ſoon abate its Force within Doors, as without.

Of this Intenſeneſs of the Cold with us, I have receiv'd Confirmations from other Places in the Southern Parts of our Iſland.

The Deſcent of the Spirits in my Thermometer on *December* 30. was within One tenth of an Inch as great as the Deſcent effected at another time (and that in a *Cold Day* too) with Artificial Freezings perform'd both with Snow and Salt, and alſo Snow and Spirits. Both which Mixtures I have ſeveral times made uſe of, and find them nearly of equal Power: If any Difference be, I have ſometimes thought the Preference due to the Mixture of Spirit of Wine with the Snow.

Although the Froſt was ſo rigorous in the Southern Parts of our Iſle, yet the Northern felt little thereof; as I have been certified by Perſons that have come from thence, as well as by ſeveral Letters. Dr. *Sloane* writes to me in general, that he hath receiv'd many Informations from thoſe Parts, which do all agree that the Winter was no way extremely cold there, but as other Winters. The Ld. *Biſhop* of

Degree *of the Froſt in* Scotland.

of *Carliſle* in a Letter to Dr. *Woodward*, ſays, " In *January* laſt, I " had a ſufficient Occaſion to take Notice of the Froſt and Cold be- " ing more Intenſe in the Southern Parts than here, and the Snow " much thicker. I began my *London* Journey on the 26*th* of that " Month, three Days before the Thaw, and aſſure you that for ſe- " veral Miles (near the Banks of the River *Eden*, in both the Coun- " ties of *Cumberland* and *Weſtmorland*) my Horſes hardly ever trod " upon Snow. When we came to *Stanemoor*, on the Confines of *York-* " *ſhire*, we found the Ground cover'd pretty thick, and the deeper " ſtill the farther we came to the South. None of our Rivers or " Lakes were frozen over; and the extraordinary Flocks of Swans " that reſorted hither (nothing of the like having been ſeen by the el- " deſt Man living) was a ſure Argument that the Temperature of Cli- " mates was ſtrangely inverted.

From *Edinburgh*, Sir *Robert Sibbald* ſays, " I can learn no extraor- " dinary Effects of the cold Seaſon here. It was a long Winter: The " Cold came early in *Octob.* and continued till near *May*. There was " much Snow, which lay long upon our South Hills near this Place. " We had not much Snow to ſpeak of, and it laſted not long.

In Ireland. In *Ireland*, I am inform'd, the Froſt was very favourable, by a Letter from Mr. *S. Molyneux*, who ſays, " They had there an harder " Winter than uſual, but judgeth they ſuffered not ſo much as their " Neighbours: They had two or three pretty hard Froſts, and ſome " Snow, but not of any remarkable Continuance, as he remembers.

Degree *of the Froſt in other* Parts *of* Europe. In the Compariſon made before between Dr. *Scheuchzer*'s Obſerva- tions at *Zurich*, and mine here, I ſaid, (*) That he noted the Cold to have been exceſſive there; but whether more than uſual, he ſaith not. But by a Letter I have lately ſeen from his Brother, it appears to have been in as great and unuſual Exceſs there, as here it was with us.

In Switzer- land.

(*) *Vid* Su- pra. S. XI.

In that Paper too I obſerv'd, to what Exceſs the Froſt arriv'd in *Italy*, *viz.* " That the Cold there was ſo great, that for 20 Years paſt, " they had not been ſenſible of a greater; and on *Twelfth-Day* it wan- " ted but half a Degree of the Extremity.

In Italy.

In Denmark. As to the *Northern Parts*, Dr. *Woodward* tells me, that in a Letter he receiv'd from Mr. *Otho Sperling*, from *Copenhagen*, he calls it *Hy- ems Atrociſſima*. And I find it noted in the Minutes of the *Royal Society* of *May* 4. 1709. " That Dr. *Judichar* ſaid the Ice was " frozen in the Harbour of *Copenhagen* 27 Inches; and that *April* 9. " *N. S.* People had gone over between *Schonen* and *Denmark* on the " Ice". Which Accounts give me a better Opinion of ſome Pa- pers I have by me, which were ſhew'd to the Society, concerning the Froſt at *Copenhagen*, ſaid to be taken from the Obſervati- ons of Mr. *Romer*. 'Tis ſaid there, " That ſuch a Froſt hath

" not been known in the Memory of Man in theſe Countries, and " that the Froſt on *January* 7. and *February* 23. $170\frac{8}{9}$. did very " nearly approach the Point of Artificial Freezing. "

In the Northern Parts of *Germany* it was much the ſame; of which I have a printed Account. The Title of the Book is, *Conſideratio Phyſico-Mathematica Hyemis proximè Præterlapſæ, &c.* being an Academical Exerciſe, perform'd in the Univerſity of *Hall*, *June* 13. 1709. by *G. Remus*, a *Dantzicker*, and printed at the ſame Place [*Halæ Magdeburgicæ.*] This Diſſertation being, I ſuppoſe, in but few Hands, I ſhall give a ſhort Account of it. — *in* Germany.

The Author having complain'd of the Defects of Meteorology, and Meteorological Inſtruments, and given ſome Directions concerning obſerving the Winds, *&c.* tells us, he had the Help of the Obſervations of three eminent Perſons in his Diſſertation about the Winter, of Dr. *Wolfius* of *Hall*; Dr. *Hamberger* of the Univerſity of *Jena*; and Reverend Mr. *Teuber* of *Ciza*. The Winter he diſtributes into five Periods. The firſt of which he begins at *October* 19. 1708. at which Time he ſays the cold Weather began with them, the Northerly Winds then blowing, and froſty Weather accompanying it. But with us at *Upminſter*, it began ſooner: For all the latter End of *September*, the Winds were Northerly, and an Hoar-Froſt on *Michaelmas*, and the following Days. After which, a great Part of *October* to the 23*d* Day, my Regiſter ſhews the Weather to have been, for the moſt part Hoar-froſty, or Froſty, very agreeably to Mr. *Remus*'s Obſervations. The End of this firſt Period he placeth on *November* 3. the ſame with our *October* 23. *O. S.* their Stile, I perceive by divers Compariſons, and Hints in his Paper, being the New Stile.

As to his next Period, which with its Interval takes in *November* and *December*, I find a pretty deal of Agreement between his Obſervations and mine, the Weather often being warm, or cold here, as it was there, and the Winds alſo not very different. Only I obſerve the Cold in one Place commonly to precede the other. Alſo the furious Wind, that he ſaith blew the Night before *December* 13. was not perceivable here 'till the ſecond Day after, *viz. December* $\left\{\begin{matrix}14\ N.S.\\3\ O.S.\end{matrix}\right.$ about Noon: At which Time it had much ſpent itſelf, and was only a briſk Eaſterly Wind, but no Storm.

The third Period he begins on *January* 5. Of which he ſaith, *Scena ſubitò mutabatur, & cum univerſæ* Europæ *admiratione cæpit Periodus, inſolito prorſus frigore notabilis.* The very ſame $\left\{\begin{matrix}January\ 5.\\Decemb.\ 25.\end{matrix}\right\}$ the Wind and Weather began here to change, as there he ſaith it did, and the Cold alſo to increaſe. The moſt remarkable Depreſſions of the Spirits there, may be ſeen with mine in this Table.

Day

Day of the Month. O. S.	*Degree of the Thermometer at* Hall, *at* 10h. *p. M.*	*Degree of the Thermometer at* Upminſter, *at* 9h. *p. M.*
Dec. 27		65
28	84½	75
29	84½	58
30	92½	45
31	100	52
Jan. 1	Totus intra	63
2	Sphæram.	54

It is to be obſerved that the Scale of their *Thermometer* runs downwards from ſome Point above, down towards the *Ball*. But the *Ball*, or the Bottom of the Stalk, being a certain Place that all Thermometers agree in, and every one is acquainted with, I therefore make the Degrees of the Scale of my Thermometers to begin at the Top of the Ball, or (which is all one) at the Bottom of the little Tube, or Stalk, and ſo reckon upwards; every Degree being one tenth of an *Engliſh* Inch; the *Freezing-Point* in my old Thermometer (here noted) at 82 *gr.* equal to 8 Inches two Tenths from the Ball; and the moſt *intenſe Cold* at 44 *gr.* But in my later Thermometers (which I now uſe, and are much nicer than my old one) the *Freezing-Point* is at 100 *gr.* ten *Engliſh* Inches from the Ball, and the moſt *intenſe Froſt* near to, or juſt in the Ball.

It may from the foregoing Table be perceived, that the Froſt kept a pretty equal Pace in both Places at its Beginning. And my Notes give me Reaſon to think it did the ſame the greateſt Part of its Duration: But I cannot be very ſure thereof, my old Thermometer (the only one I then had) happening to be broke on *January* 11. For which Reaſon I am unable to give ſuch another Thermometrical Table of his next Period, as I have done in this.

This third Period he makes to end *Jauuary* {25 *N. S.* / 14 *O. S.*} with a Weſterly Wind, and a Thaw, which held for a few Days. With us the Wind was Southerly at the ſame Time, and a Thaw accompanying it for a few Days likewiſe.

The fourth Period he begins *January* {31 *N. S.* / 20 *O. S.*} in which I obſerve there is a great Agreement between our Obſervations as to the Cold; and thoſe Days on which he noteth the Weſterly Winds

to

to have been ſtrong, it was the ſame here. And ſome Agreement alſo, but leſs, is in the coaſting and ſhifting of the Winds throughout this Period.

The fifth and laſt Period he placeth between *February* $\left\{\begin{smallmatrix}17\\6\end{smallmatrix}\right.$ and *March* $\left\{\begin{smallmatrix}17 & N.S.\\6 & O.S.\end{smallmatrix}\right\}$ In this, he ſays the cold Weather returned, and continued long: And the ſame it did with us. But as to the end of this Period, I find ſome Difference, and ſome Agreement between our Obſervations. The Snow was more with them than us; the Winds changed with us from the Eaſterly Points, to the Weſterly and Southerly, a Day or two ſooner than with them; then agreed with them; and ſoon after veer'd about to the Eaſterly and Northerly, as it did with them. And I obſerve, that when the Winds agreed in both Places, my Notes ſhew the Wind to have been of ſome Force here.

As to the Warmth of the Weather all this time, I find a pretty deal of Agreement; only as the Wind changed two Days ſooner here, ſo we had the mild Weather, he mentions, two Days ſooner: Then it grew colder here, as he ſaith it did with them. And Whereas he noteth *April* $\left\{\begin{smallmatrix}13 & N.S.\\2 & O.S.\end{smallmatrix}\right\}$ to have been the firſt Day on which the Spirits roſe to the Point of Warmth, I found by my Thermometer the Day before to have been as warm as that, as alſo were the following Days; and each of them warmer than had been all the preceding Winter; but yet that we had divers warm Days before that Time, particularly *March* 12, 13, 14, 18, 19, 28. *O. S.* were warm Days, but the reſt in that Month for the moſt part cold.

The Effects *of the* Froſt *on* Fluids.

The Waters were the firſt Thing that felt the dire Effects of this Froſt. And theſe were in many Places frozen to an extraordinary Depth; although I hardly believe to that Depth, as in the Long Froſt in 1683. Of which Froſt we have a ſufficient Inſtance in our River of *Thames*; whoſe Waters were ſo frozen, that above Bridge, 'tis well known, many Booths were erected, Fires made, and Meat dreſs'd; and on *January* 10. $168\frac{3}{4}$, I ſaw a Coach and two Horſes drive over the River into *Southwark*, and back again, a great Number of People accompanying it. But this laſt Winter the Caſe was greatly different, according to the Account I receiv'd from Mr. *Lowthorp*, who ſays, "He ſaw ſeveral People croſs the "*Thames* at ſome Diſtance above the Bridge: But that was only to-"wards Low-water, when the great Flakes of Ice that came down, "ſtopp'd one another at the Bridge, till they made one continued "Bed of Ice from thence almoſt to the *Temple*. But when the "Flood came, the Ice broke, and was all carried with the Current "up the River. I was told the like happened between *Weſtminſter* "and *Lambeth*, a little above *Whitehall*.

As for other Waters, they alſo had their Share; eſpecially where they lay expoſed to the Northerly and North Eaſterly Winds. The Sea-waters were cover'd with Ice in many Places near the Shore, in Harbours, and where they lay calm and ſtill. Of this I have already given a pregnant Inſtance in the Harbour of *Copenhagen*, and the Sea between *Denmark* and *Schonen*. And in a Letter from Dr. *Newton*, he tells me, "The Sea was frozen both on the Coaſt "of *Genoa* and *Leghorn*.

As for the Northern Parts of *Germany*, the laſt cited Diſſertation gives this Account of its Effects on Fluids: *Aqua infra ſolitam profunditatem in glaciem abiit, & alii liquores congelati apparuere, qui alias extra congelationis periculum mediâ hyeme conſtituuntur. Fons in quodam* Sileſiæ *pago, qui cum aliàs æſtate frigidus, hyeme calidus deprehendatur, hac tamen hyeme ſpiſſa ſatis glacie non ſine omnium admiratione obductus fuit. Certè* Novellæ *publicæ aliquoties Thermas in glaciem converſas nuntiarunt: Id quod tamen calidioribus non accidit* . . . . . Halæ *ſtrias fontibus ſalſis adhærentes vidimus, id quod intra ſeculi ambitum non contigiſſe fertur. Per literas me certiorem reddidit* D. Breynius, *ipſum mare, quouſque oculorum acies etiam armata penetrare poterat, adhuc d.* 8 Aprilis *glacie tectum fuiſſe. Cum is Lixivium cineribus clavellatis ad ſaturitatem ferme imprægnatum aeri expoſuiſſet, licet nunquam congelare ab hominibus, qui pluribus annis id tractaverunt, aſſereretur, brevi tamen tempore in glaciem converſum eſſe expertus. Addit, amicum quendam ſuum Tartari quoque ſpiritum dephlegmatum congelatum obſervaſſe. Referunt obſervationes* Halenſes *Sputum ex ore vix dimiſſum in glaciem abiens* . . . . . *Fluvii ter in glaciem abiere, etiam illi, quibus ob celeritatem, qua feruntur, frigus aliàs non infeſtum.* Thus far D. *Remus*.

Theſe Effects, I am apt to think, the Waters felt not only in *England*, *Denmark*, *Germany*, *France* and *Italy*; but in all the *Northern World* alſo, excepting *Scotland*, *Ireland*, and probably ſome other Iſlands, or Places near the Sea; altho' even ſome of theſe appear from the foregoing Account to have been great Sufferers too. This Univerſality of the Froſt, I ſuſpect from the Multitudes of divers kinds of Birds (utter Strangers to theſe Parts, and many of them Inhabitants of the Northern colder Countries) which were ſeen and kill'd in many Parts of *England*. In our *Eſſex-Marſhes*, we had many wild Swans, Brent-Geeſe, many of the rarer Gull-kind, and divers other ſorts of Birds, utter Strangers to theſe Parts. Mr. *Bellers* gave Dr. *Woodward* this following Catalogue of Birds kill'd within four or five Miles of *Coln St. Aldwins*, or *Edwins*, in *Glouceſterſhire*, between the Beginning of *November*, and the latter End of *March* 1708, which he ſaith are never found there in moderate Winters.

1. *Lanius cinereus major*, the greater Butcher-Bird, or Mattageſs; ſometimes ſeen in *Derbyſhire*, but commonly in *Germany*, as Mr. *Willoughby*

loughby ſaith. 2. *Fringilla montana*, the Brambling. 3. *Numenius, ſive Arquata*, the Curlew. Theſe Birds, though Strangers to the inland Parts, I have ſeen common enough on the Sea-coaſts of *Eſſex*: And Dr. *Woodward* ſays, he ſaw them ſeveral Times this laſt Winter at the *Poulterers* in *London*. 4. *Gallinula Erythropus major*, the Red-ſhank, or Pool-Snipe. 5. *Gallinula Hypoleucos Geſneri*, the Sand-piper. 6. *Schæniclos*, the Stint. 7. *Corvus aquaticus minor, ſive Graculus Palmipes*, the Shag. 8. *Merganſer*, the Gooſander. 9. *Mergus cirratus longiroſter*, the Dun-diver. 10. *Mergus major cirratus*, the Smew, or white Nun. 11. *Colymbus major*, the Greater Loon. 12. *Larus major*, the Greater Gull. 13. *Cygnus ferus*, the Elk, or Hooper, or Wild Swan. 14. *Brenta*, the Brent-Gooſe. 15. *Anas niger Aldrovandi*; ſeldom ſeen in *England*, but frequent in *Norway*. 16. *Tadorna*, the Shell-Drake, or Burrough-Duck. 17. *Anas Fuligula prima Geſneri*, the Tufted-Duck. 18. *Anas fera fuſca Geſneri, Penelops Veterum*, the Poker. 19. *Anas Platyrhynchos mas Aldrov*, the Golden-Eye. 20. *Anas Platyrhynchos roſtro nigro & plano*, the Cadwall.

Effects of the Froſt on Animals.

In the Diſſertation before-cited, we are told, how Animals ſuffered both with them, and in other Places; " That the Freſh-water *Fiſh* " were every where kill'd in their Parts, and that a vaſt Deſtruction " befel their *ſmall Birds*. Both which, he is inform'd, happen'd in " his own Country alſo at *Dantzick*. Nay, ſome did not ſtick to af- " firm, that they ſaw Birds, as they flew along, drop down out of " the Air, their Strength failing: That the *Luſatia Letters* ſaid, ma- " ny Cows were frozen to Death in their Stalls. And many Travel- " lers on the Road were ſome quite frozen to Death, others loſt their " Hands, Feet, Noſes or Ears; and others fainted, and were in great " Danger of Life or Limb, when brought too ſoon near the Fire. Of " theſe Particulars, he gives divers Inſtances from their News Papers; " of two Gentlemen, and a Smith in *England*, and above 60 Men, and " many Cattle near *Paris*; and the like at *Venice*, and 80 *French* Sol- " diers near *Namur*, all kill'd on the Road, with the Cold". Whether any ſuch Perſons periſhed on our Roads in *England*, I have not heard: But we were told of ſome that did; particularly ſome Poſt-Boys, and, I think, ſome Drovers. Our Freſh-water Fiſh were, many of them, deſtroyed, in Ponds that were ſhallow, and eſpecially if long frozen over; ſome for want of Air, where the Ponds were not kept open; and ſome with the cold Air at the Holes in the Ice, where in great Numbers they came to get Breath. On the *Italian* Coaſt ſome of our " Mariners on Board our Men of War, died of the Cold; " and ſeveral loſt Parts of their Fingers and Toes: As Dr. *Newton* informs me.

But the greateſt Sufferers in the Animal-Kingdom, were *Birds* and *Inſects*. *Robin Redbreaſts*, which before the Froſt were numerous, are ſince that very ſcarce about us; and notwithſtanding their Recruits in the following Summer, yet even ſtill, in this ſucceeding Winter, their Scarcity remains. *Larks*, both *Wood* and *Sky-Larks*, became, in a Manner, Rarities in our Country the following Spring and Summer; nor are they as yet become ſo numerous as heretofore. But whether this was an univerſal Calamity that befel that Family of Small Birds, or whether it only happen'd to our *Eſſex-Larks*; or whether they were not driven from theſe Parts by the Froſt, I cannot ſay; becauſe I have been told, that in ſome other Counties of *England*, which abound in large common plough'd Fields, and where Larks are commonly more numerous than about us, they have had large Flights of Larks this preſent Winter 170$\frac{9}{10}$. But I have enquired of the *London* Poulterers, and they tell me, they have Larks from almoſt all Parts of *England*, and have not this following Year receiv'd a Quarter, ſcarce a tenth Part, of the Larks they uſed to have; by reaſon the Froſt kill'd them, as the Bird-Catchers ſay.

In the *Inſect-Tribe*, I have particularly obſerv'd the *Death-Watch*, to be great Sufferers; notwithſtanding that Inſect's great Precaution, and Art, to ſecure itſelf againſt the hard Weather, in dry Places within Doors, under downy light Duſt, *&c.* Few of them appear'd the following Summer; and in Places where they uſed in *July* to be very ſonorous with their ticking Noiſe, only now and then one was heard; a manifeſt Sign of their being either kill'd, or render'd leſs fertile and venereous.

Effects of the Froſt on Vegetables.

But among all the Sufferers by the Froſt, the *Vegetables* were the moſt univerſal; few of the tender Sorts eſcaping. About us, *Bays*, *Roſemary*, *Cypreſſes*, *Myrtles*, moſt of the *Phillyrea*'s, even *Junipers*, among Shrubs; and *Artichokes*, *Colly-Flowers*, and a great many other Olitory Plants, ſuffer'd greatly. By Enquiries made on Purpoſe among the *London Gardeners*, I have been inform'd, ſome of them have loſt to the Value of 80*l.* 100*l.* 200*l.*

But the moſt exact Account I have met with, is from Mr. *Ja. Bobart* of the *Oxford* Phyſick-Garden. He takes Notice, that the Damages of this Froſt do not come up to thoſe in 1683; which Froſt being of longer Continuance, cleft the *Oaks*, and Bodies of the *Vines*, &c. But in the laſt Froſt there were Intervals of Relaxation, beſides ſeveral conſiderable Snows, which prov'd a good Guard to many Plants. But the Snow melting, and the Cold withal continuing, prov'd of evil Conſequence to many bulbous, and tuberous Roots, and abundance of other Things. "But (he ſays) the ſharp, dry, and "cutting Winds from the North, and North-Eaſt, were deſtructive

to

" to many of the Ornaments of our Gardens, which before ſeem'd " to be almoſt naturaliz'd to our Clime; as *Cypreſs*, *Bays*, *Roſemary*, " *Alaterni*, *Phillyrea*'s, *Arbuti*, *Lauruſtines*, &c. as alſo to moſt of our " fruteſcent Herbs, ſuch as *Lavenders*, *Abrotonums*, *Rue*, *Tyme*, and " divers others of ſuch Race, eſpecially ſuch as had their Heads a- " bove the kind Covering of the Snow. And not ſuch Exoticks " only, but ſome of our own Natives, as is viſible in moſt of our " *Furze-fields*, and divers *Hollies*, eſpecially of the finer ſtrip'd Race, " have felt the Smart of ſuch the Vigour of the Seaſon, by the Loſs " of their Leaves, and ſometimes their Lives.

" And what hath been more obſervable this Year, than in others, " is, the Sap of our finer mural Fruit-Trees, as of *Peaches*, *Nectа-* " *rines*, *Apricocks*, &c. was ſo congeal'd and diſorder'd, that it prov'd " ſtagnated in the Limbs and Branches, and equal to Chill-blains in " Humane Bodies; which, in too many Parts of the Tree, turn'd to " ſo frequent Mortifications, that it is very much to be doubted, whe- " ther ſufficient Vigour is ever to be expected from them, to be worth " their ſtanding, notwithſtanding their weak Endeavours of ſhoot- " ing.

" And it is no leſs obſervable, that the very Buds in theſe finer " Trees, as well Leaf-Buds, Bloſſom-Buds, (which are but the Ova- " ries of the ſucceeding Fruits) were quite kill'd, and dry'd into a fa- " rinaceous Matter, by the too great Sharpneſs of the Cold, before " they grew out, though Life remain'd in the Branch.

" The *Plumbs*, being more hardy, produc'd their Bloſſoms well " enough; but through the chilling Wets, which happen'd too plen- " tiful about that Time, and the great Defect of nutritive Warmth, " they grew weak; with their little Stalks, or Pedicles, languiſh- " ing, and turning yellow, generally dropt off, and came to no- " thing.

" It might reaſonably have been ſuppos'd, that ſuch conjoin'd Cold, " with repeated Wets, ſhould have deſtroyed the injurious *Inſects*, " which uſually infeſt the firſt Product; but even in this Year, they " have prov'd vivid, in too great Plenty among the *Apples* and *Pears* " (eſpecially the former) whoſe Bloſſoms, as well as Leaves, have been " a Pabulum for theſe voracious *Erucas*, whoſe Eggs lay dormant all " the Winter, ſo dry in their Bags, that there were ſo many eſcap'd " from being frozen, that in many Places they prov'd enough to de- " ſtroy the whole Verdure.

" *Fig-Trees*, whoſe ſofter Texture was more eaſily penetrated, have " ſuffered much, moſt of them being cut down.

" Many *Exotick Greens*, and rare Plants coming from *Africa* and " other warm Regions, have mightily ſuffered, eſpecially in ſuch Stoves " and Conſervatories as had not Fire enough.

What

What he obſerveth concerning the Deſtruction of *Wheat*, was, I believe, a general Calamity, as alſo the Particulars he takes Notice of much the ſame in other Places too, *viz.* " Where the Land was poor, " and coldly expoſed, there the *Wheat* was kill'd; that many Lands " of Wheat eſcaped tolerably well on the warm Side, when the other " Side was quite kill'd with the Extremity of Cold.

By the *warm and cold Sides*, I ſuppoſe our Obſerver means the ſunny and ſhady Sides. But with us the Wheat ſuffer'd rather more on the Southern, ſunny Side, than the Northern; I ſuppoſe by reaſon the Ground was ſomewhat open'd by the Sunſhine, and the covering of Snow melted, and Way thereby made to the Severity of the nocturnal Froſt. Upon which Account I have heard it ſaid by ſome Obſervers, *that Vegetables ſuffered more the laſt Winter from the Sun, than the Froſt.*

In *Eſſex* alſo, I obſerved many ſmall Fields of three or four Acres of Wheat, to eſcape pretty well, where fenced with thick high Hedges againſt the cold Winds, eſpecially where they were cover'd long with Snow; at leaſt they came off better than other Parcels of Land expoſed to the Winds, that diſlodg'd the Snow, and aggravated the Cold alſo. So at *Upminſter*, the beſt Pieces of Wheat were ſuch, I obſerv'd, as lay on gentle Deſcents facing the Weſt or S. W. eſpecially when guarded on the Eaſtern Side with a Hill, or a Wood; which fenced off the cold piercing Eaſterly and North Eaſterly Winds.

Not only *Shrubs* and *Plants*, but the *larger Trees*, have in ſome Places had their Share of Suffering too. But it was obſerv'd by ſome Perſons of the *Society*, that the Calamities which befel Trees, aroſe not purely from their being frozen, but principally from the Winds ſhaking and rocking them at the ſame Time, which rent and parted their Fibres.

Theſe have been ſome of the moſt remarkable Effects of the Froſt on the *Vegetables* of the more *Southerly* Parts of our Iſland, the *Northerly* eſcaping better. From *Edinburgh*, Sir *Rob. Sibbald* ſays, " The " Corn did not riſe, and ripen, ſo ſoon as wont; but there hath been " a plentiful Harveſt, well brought into the Barns and Yards. And " the Price of Victuals (which was high) falls lower daily. There " was no greater Number of thoſe who died, than was uſual during " the Winter formerly.

As to other Places, I find the Effects were, in the more Southerly Parts of *Europe*, much the ſame on their Vegetables as on ours. In *Italy* Dr. *Newton* ſaith, " Almoſt all the *Lemon* and *Orange-Trees* " with thoſe of the like Kind, are deſtroyed in this Countrey by the " Froſt, and a great many *Olive-Trees*. The Leaves of the *Bay-Trees* " have the ſame Colour now, as all others have when they are falling " in *October*. Beſides which, there are two other Accidents he tells me of, owing probably to the Froſt. One happen'd at *Florence*, where

where, " on the ſide of a Hill were formerly many Buildings, " which twice falling down, by the Earth giving way, a Wall was " erected in the Time of this great Duke's Grandfather, with an " Inſcription on the Wall, which ſeparates the Ground from the " next Street, that for the future no Perſon ſhould build there. " After the Great Froſt, this Wall hath fallen down too. The " Hill is full of Stones, and they will have it, that as thoſe in- " creaſe, the Ground is puſh'd forward, and thereby thrown down. But I am apt to think, the Froſt might have a great Concern herein.

The other Accident was at *Piſa*, " where, upon the melting of " the Snows, and the great Rains which fell after the Froſt, altho' " the *Arno* did not ſwell over the Banks at *Piſa*, yet the Water at " ſome Diſtance from the River, in a middle Row of Houſes be- " twixt the River and the great Street on the Northſide, with great " Violence broke out, and if it had not been immediately perceiv'd, " and the Breach ſtopp'd by the throwing in of a great Quantity of " Bricks and Timber, that Part of the Town might have been in " in Danger of being drowned, where the *Palace*, and the *Publick-* " *Schools*, or (as they call it) the *Sapienza* ſtand.

Dr. *Mich. Angelo Tilli*, tells me from *Piſa*, " That the Froſt hath " deſtroy'd a World of Trees both in City and Country about " them.

In *Switzerland*, among the high *Alpine* Ridges, they felt dire Effects of the Froſt; yet ſome Places eſcap'd. Of which Dr. *Woodward*, imparted to me the following Account from Mr. *John Scheuchzer*, " Effectus triſtiſſimos, quos Hyeme præteritâ ſenſêre Arbores noſtræ, " etiam craſſiſſimæ, præſertim *Juglandes*, *Vites*, non prorſus ſenſêre " loca quædam præaltis verſus Septentrionem jugis munita. *Veſenæ* " ad Rivarium-Lacum ſalvæ manſêre Arbores & Vites, ut Vinde- " mia (apud nos nulla) ibi ſit copioſa; Juglandes fructibus oneratæ, " uti quoque arbores reliquæ, ac ſi in diverſo ſuccreviſſent a vici- " nis locis Climate. *Galandæ*, montis altiſſimi in confiniis *Rhætorum* " & *Sarunetum*, radicibus adjacet pagus *Vettis*. Hujus incolæ vix " unquam mitiorem Hyemem habuiſſe teſtantur, dum interim in- " colæ Pagi proximi *Valentiæ*, ſupra Thermas Fabarias ſiti, durante " ſummo Frigore, aditu mutuo prorſus intercluſo, veriti fuêre, ne " *Vettienſes* omnes frigore perirent. E contrà Sylvæ Boreæ expoſi- " tæ, & Arboribus etiam vivaciſſimis, Abietibus, Taxis, Laricibus " conſitæ, quaſi aduſtæ rufum induere colorem, foliiſque nudatæ.

As to the Northerly Parts of *Germany*, the Caſe was there after the manner it was with us; as Mr. *Remus* informs us. " Arbores " & frutices ultra nivis ſuperficiem prominentes magno numero " Frigus deſtruxit. Ceraſus, Malus, & Prunus riſere Hyemis minas. " Multa ramorum ſegmenta menſe adhuc Martio Microſcopio ſup-

" poſuit

" poſuit D. Præſes [Dr. *Wolfius*] nec quicquam integritati & tur-
" geſcentiæ fibrarum deeſſe deprehendit ..... Flores copioſi in
" Ceraſo, rariores in Malo, &c. ..... Nuces Amygdalæ, Mali
" Perſicæ & Mali Armeniacæ nobiliores pariter ac ignobiliores, Ro-
" ſarum frutices tantum non omnes interierunt, Pyri plurimum
" damni perpeſſæ. Vites ſub terrâ defoſſas & ſatis tectas a frigoris
" ſævitie immunes vidimus, at reliquas contra illud non ſufficien-
" ter munitas prorſus deſtructas & ipſi conſpeximus, & Novellæ,
" &c. ..... Commemoranda vero ſunt .... quæ D. Præſes an-
" notavit. Cum ſtatim ab æquinoxio, nive liquefactâ, & glacie re-
" ſoluta, aditus in Hortos pateret, Cortex, Lignum, & Medulla
" in iis arboribus, quibus Frigus infeſtum fuerat, *e. g.* in Pyro &
" Malo Armeniacâ, nigricabant. Unde multi .... extirpabant.
" Cum ſegmenta ramorum, qui præteritâ æſtate adoleverant, mi-
" croſcopiis ſubjicerentur, fibrillæ hinc inde diſruptæ, non ſecus ac
" in ligno putrido, conſpiciebantur: In reliquâ autem ramorum
" parte nulla iſtiuſmodi diſruptio notari poterat, ſuccus unice defi-
" derabatur & viriditas. Enimvero cum circa medium Apri-
" lis arbores calore Solis foverentur, in Malis Armeniacis ex lig-
" no ſeniore paſſim novæ Gemmæ erumpebant, in quibuſdam etiam
" ex juniore ibi proveniebant, ubi flores progerminare debuerant;
" in nonnullis nullus ſurculus protruſus. Pyri Gemmæ omnes evo-
" lutæ, & Flores prodiere; conſueto tamen vigore plerumque de-
" ſtituti, atque hinc nulla Fructuum rudimenta reliquentes. Tunc
" temporis viriditatem plenariam conſequebatur Cortex, nigrior ex
" centro Medullæ verſus peripheriam migrabat, Ligni ſubſtantia
" candorem recuperabat. Fibrillæ novi anni adhuc nigricabant,
" per Microſcopium tamen conſpectæ non minùs ac fibrillæ eædem
" in Ceraſo & Malo, quas frigus intactas reliquerat, ſucco turgeſ-
" cere videbantur. Equidem medulla ſub Gemmis inſolitâ nigredi-
" ne paſſim tingebatur; radicula tamen Gemmæ in ſurculum pro-
" truſæ admodum turgida & virens oculo armato ſiſtebatur ....
" Notabile vero, quod, quemadmodum Frigus Pruno, ita etiam gem-
" mis Malorum Armeniacarum intra corticem ſurculorum Pruni
" immiſſis pepercerit, in proceras frondes nunc excreſcentibus juxta
" arbores ſui generis, quibus ne unicam Gemmam intactam reliqueſ-
" rat Frigus.

As to the *Cauſes* of this Great Froſt, they are, I confeſs, to me ſo very much hidden, that I intended wholly to have paſs'd over that Matter. But Mr. *Remus* having ingeniouſly enquir'd into them, I ſhall briefly give his Opinion.

The Cauſes of the Froſt.

The Fountain of Heat enjoy'd by the Earth, being the Sun, and that Heat being not always the ſame, he enquires into the Reaſon why it is not ſo. The Variation of the mutual Diſtance between the Earth and Sun at the Apogee and Perigee; the Mutuation of the

the Earth's Place in Reſpect of the Heavens, or its being juſtled at a greater Diſtance from the Sun, and the Obſtruction of the Solar Rays by the Spots on the Sun, he rejects. And as to the true Cauſes, having aſſign'd good Philoſophical Reaſons for the perpendicular warming more than the oblique Rays, for the Wind cooling the Air, and the North and Eaſt more than other Winds, *&c.* he then enumerates his Cauſes in theſe Words: *Nimirum ex parte Solis requiritur ingens a vertice diſtantia, & exigua ſupra Horizontem mora: Ex parte Telluris verò, Atmoſphæra exhalationibus plena, & nubibus gravida; Ventique Orientales & Septentrionales, præſertim impetuoſi requiruntur. Omnium autem maximè neceſſarium, ut actiones Solis & diu & tum imprimis impediantur, quando cauſæ Frigoris concurrunt.*

Having aſſigned his Cauſes, he applies them to his five Periods, and the more remarkable Accidents that happen'd in them.

But after all, there are ſome other more hidden extraordinary Cauſes, that he hath not reach'd. For we have all his Cauſes very commonly concurring in other Winters, without the ſame Effects as in the laſt. This preſent, next ſucceeding Winter $17\frac{0}{1}\frac{2}{0}$, we have had (beſides what is common to all Winters, the Obliquity of the Sun's Rays, *&c.*) the Winds as much Northerly and Eaſterly, and as ſtrong; and as much dark Weather; and all concurring too together, as happen'd during the Great Froſt: And yet no more than ordinary ſevere Weather.

But as to miſty, cloudy, dark Weather, which he reckons among his principal Cauſes, I am ſo far from thinking it a Cauſe, that I rather take it to be the Reaſon we have not more frequent ſevere Froſts, at leaſt in our Iſland places, ſurrounded by the warm Vapours of the Sea. Clouds and Vapours do indeed intercept, and keep off the Sun-beams; and probably imbibe and retain a great deal of Warmth themſelves; nay, perhaps they may (as he ſaith) reflect back ſome of the Sun-Rays: But we conſtantly in Winter find, that the fewer the Exhalations are, and the clearer the Air, and after the Warmth of the Sun by Day, the ſharper the Froſt is at Night.

I do not pretend to aſſign Cauſes; yet thus much ſeems to me reaſonable: That the great Mint of Meteors being the ſuperior Regions of the Air, and the Source of Exhalations being the Terraqueous-Globe, in thoſe two Places we are to ſeek for the farther, and more grand Cauſes of the late Froſt. And in the fourteen and more Years Obſervations I have made of the Weather, *&c.* I have found a great deal to be attributed to the Increaſes and Decreaſes of the Cold of the upper Regions, as alſo to the inner Diſpoſitions of our Globe, at leaſt to the greater or leſs Plenty of Vapours and Exhalations. But not as yet having Obſervations enough to clear and demonſtrate my Hypotheſis, I ſhall defer what I might have ſaid.

Effects of Thunder and Lightning *in* Ireland, *communicated by* S. Molyneux *Esq*; n. 313. p. 36.

XVIII. 1.] Strange were the Effects of the Thunder and Lightning which happen'd at Mrs. *Close*'s Houſe at *New-Forge* in the County of *Down* in *Ireland*, on the 9*th* of *Aug.* 1707. I waited on her about a Fortnight after to inform myſelf of the Particulars. She told, that the whole Day was cloſe, hot, and ſultry, little or no Wind ſtirring till towards the Evening; that there was a ſmall Breeze with ſome miſling Rain, which laſted about an Hour; that as the Air darken'd after Sun-ſet, ſhe ſaw ſeveral faint Flaſhes of Lightning, and heard ſome Thunder-claps as at a Diſtance; that between 10 and 11 of the Clock, both were very violent and terrible, and ſo increaſed, and came on more frequent till a little before 12 of the Clock; that one Flaſh of Lightning, and one Clap of Thunder came both at the ſame Time louder and more dreadful than all the reſt, which, as ſhe thought, ſhook and inflam'd the whole Houſe; and being ſenſible at that Inſtant of a violent ſtrong ſulphureous Smell in her Chamber, which ſhe did not perceive before, and feeling a thick groſs Duſt falling on her Hands and Face as ſhe lay in Bed, ſhe concluded that Part of her Houſe was thrown down by the Thunder, or ſet on Fire by the Lightning; that ariſing, and calling for Candles, ſhe found her Bed-Chamber full of Smoak and Duſt, as alſo the Kitchin that was beneath it: The reſt of the Houſe being ſafe, ſhe only obſerv'd the Looking-glaſs, that hung in her Chamber, to be broken.

The next Day ſhe found, upon further Search and Enquiry, that Part of the Top or Corniſh of the Chimney, which ſtood without that Gabel-end of the Houſe where her Chamber was, was ſtruck off; that Part of the Copeing of the Splay of the Gabel-end itſelf was broken down, and the Shingles on the Roof adjoining thereto (to the Number of 12 or 16) were raiſed or ruffled, but none ſhatter'd or carry'd away; that Part of the Ceiling in her Chamber beneath thoſe Shingles was forc'd down, and Part of the Plaiſter and Pinning-ſtones of the adjoyning Wall, was alſo broken off and looſen'd, (the whole Breach 16 or 20 Inches abroad.) That at this Place there was left on the Wall a ſmutted Scar or Trace, as if made black by the Smoak of a Candle, which was directed downwards towards another Place on the ſame Wall whereon a Breach was alſo made as the former, and of the ſame Dimenſions, Part of which was behind the Place where the Looking-glaſs did hang; that the Boards on the Back of a large Hair-Trunk full of Table and other Linnen, ſtanding beneath the Looking-glaſs, were forc'd in, and ſplinter'd as if by the Blow of a Smith's Sledge; that two Parts of three of the Linnen within this Trunk were pierced or cut thro', the Cut appearing of a Quadrangular Figure, and between two or three Inches over; that the End of the Trunk was likewiſe forc'd out, as the Back was drove in; that at about two Foot diſtance from the End of this Trunk (where the Floor

and the Side-Wall of the Houſe joyn'd) there was a ſmall Breach made in the Plaiſter, where a ſmall Chink or Crevice was to be ſeen between the ſide Board of the Floor and the Wall, ſo wide as that a Man could thruſt his Fingers down; and that juſt beneath this, again in the Kitchen, the Cieling was forced down, and ſome of the Lime or Plaiſter of the Wall broke off; that exactly under this again, ſtood a large Tub or Veſſel of Wood incloſed with a Crib made of Brick and Lime, which was broke and ſplinter'd all to Pieces, and moſt of the Brick and Lime-Work about it forc'd and ſcatter'd about the Kitchen.

I went from Place to Place, viewing each Particular; and as I found all was done on or near the Gable-end of the Houſe, I have endeavoured to explain it by a Draught, wherein the ſeveral Breaches are diſtinguiſh'd: And as I conceiv'd all to be effected by ſome irreſiſtible Body, I have alſo by two Parallel Lines traced out its irregular Motion. *Fig.* 9.

The Looking-glaſs was broke with that Violence, that there was not a Piece of it to be found of the Largeneſs of Half a Crown: Several Pieces of it were ſticking like Hail-ſhot in the Chamber-Door (being of Oak) and on the other Side of the Room; ſeveral of the Edges and Corners of ſome of the Pieces of the broken Glaſs were tinged of a light Flame Colour, as if heated in the Fire; the Curtains of the Bed were cut in ſeveral Pieces, thought to be done by the Pieces of the Glaſs; ſeveral Pieces of Muſlin and Wearing Linnen, left on a Trunk, were thrown and ſcatter'd about the Room, no way ſinged or ſcorched; and yet the Hair on the Back of the Trunk, where the Breach was made, was ſinged; the uppermoſt Part of the Linnen within the Trunk was ſafe and well, and the lowermoſt Parcel, conſiſting of 350 odd Ply of Linnen, pierced through, of which, none was any way ſmutted, but the uppermoſt Ply of a Table-cloth that lay above all the reſt. She told me, there was a yellow Singe or Stain perceivable on ſome Part of the other Linnen ſo damag'd the next Day; and the whole Linnen ſmell'd ſtrong of Sulphur; but neither this yellow Stain or Smell was perceivable when I was there: That the Glaſs of two Windows in the Bed-Chamber above, and two Windows in the Kitchen beneath, was ſo ſhatter'd, that there was ſcarce one whole Pane left in any of them; that the Pewter, Braſs, and Iron Furniture in the Kitchen were thrown down, and ſcatter'd about the Kitchen, particularly a large Girdle about 20 Pounds Weight, that hung upon an Iron Hook near the Cieling, was found lying on the Floor: that a Cat was found dead the next Morning in the Kitchen, with its Legs extended as in a going Poſture, in the Middle of the Floor, with no other Sign of being hurt, than that the Furr was ſinged a little, about the ſetting on of the Tail.

She told me too, that about ſome few Days before this Accident happen'd, ſhe remov'd a Table Preſs-Bed from the Place where the Hair-Trunk ſtood, wherein two little Girls (her Daughters) uſed to lie; which ſhe look'd upon as a particular Piece of Providence.

The Wall both above and below a little Window in the ſame Gable-end, was ſo ſhatter'd at the ſame Time, that the Light could be ſeen through the Crevices in the Wall; and that upon a large Stone on the outſide of the Wall beneath this Window, was to be ſeen a Mark, as if made by the Stroke of a Smith's Sledge, or large Iron Crow, with which a Splinter or Piece of the Stone was broken off of ſome Pounds Weight. I was further informed, that from the Time of that great Thunder-clap, both the Thunder and Lightning diminiſh'd gradually, ſo that in an Hour's Time all was ſtill and quiet again.

—*at* Ipſwich *by Mr.* O. Bridgman, n. 316. p. 317.

2.] There happen'd at *Ipſwich* on the 16*th* of *July* 1708, a moſt violent Storm of Thunder and Lightning; it began about Six to be perceiv'd at ſome Diſtance, and aroſe in the South-Weſt. I was then on the higheſt Eminence about this Town, whence I could plainly diſtinguiſh the working of the Storm: The Inſtant I perceiv'd the Flaſh (which I judg'd to be about four Miles diſtant) it ſeem'd to extend it ſelf like a Bow, and caſt its Light a conſiderable Way round it, and the Shaft of Lightning (if I may ſo call it) did not run in a waving angular Figure, as uſual, but in a ſtraight Shaft of Fire, like the Fuze of a Bomb, directly from the Cloud to the Ground; upon which, and finding the Storm approach, I haſten'd Home; and ſoon after, we had two or three prodigious Flaſhes of Lightning, and the Noiſe of the Thunder that ſucceeded them was ſo great, and caus'd ſuch an Emotion in the Air, that it made the Rooms ſhake, and the Windows rattle, as in a great Storm of Wind. Dr. *Dade* aſſur'd me, that at that Time the Lightning ſeem'd to dwell ſome conſiderable Space on the Ground, and that he could very plainly feel the Heat of it in his Face. The Paſſage-Boat was at that Time coming from *Harwich*, and juſt got to the Town, when a terrible Flaſh came, which kill'd the Maſter, and three more Perſons that were on Board. I ſaw one of them the next Day; he had a Wound in his Thigh, his Breaſt was lacerated, as if he had been whipp'd with Wires, and his Face and Body as black, as if he had been blown up with Gunpowder, and Thouſands of ſmall black Spots about him. The Maſter of the Veſſel was not at all diſfigur'd, had only one Wound on his Side, like a freſh Burn, no other Mark about him; the Chain of his Watch was melted, yet no Burn could be perceiv'd on his Breeches or Cloaths. The third Perſon was very much torn and ſhatter'd about the

the Head, the Crown of his Hat was taken clear out, as if it had been cut out, and ſeveral Parcels of his Hair drove into the Subſtance of the Hat. The fourth was very little disfigur'd, only a black Spot on his Side, and a ſmall Wound, as if made with a cauterizing Iron. There were ſeveral others a-board wounded and ſtunn'd. One *Artis* had his Hair burnt cloſe to his Head behind, and his Peruke untouch'd: He had a Scratch on his Arm about four Inches long, and a ſmall Hurt below the Elbow; he fell that Night into a violent Fever, grew delirious, and is pronounc'd irrecoverable. Whether he receiv'd any Hurt on his Brain, or the Violence of the Fever cauſes the Delirium, remains undetermin'd. There was no Mark to be ſeen on his Coat, Waſtecoat, or Shirt, where he had his Hurt on his Arm. Two of the Perſons kill'd, were on the outſide, and the other two under the Tilt of the Boat; and what is pretty remarkable, the two that were within the Tilt, ſate on each Hand of a Woman, that receiv'd no Damage. One Perſon had the Soal of his Shoe unripp'd from the Leather, and no other Damage. I wonder the Blaſt lighting ſo directly on the Boat, did not ſhatter it all to Pieces: There was another Boat that follow'd them, and receiv'd no Damage, and took out the reſt of the poor frighted Wretches; the Maſter of which does affirm, he ſaw the Fire light on the Bow-ſprit of the former Boat, where meeting a ſmall Reſiſtance, it flew into ſmall Streams like a Rocket, part into the Boat, part into the Water; which, if true, no doubt, was the Cauſe of the Miſchief being done in ſo many different Parts of the Boat; and does in ſome Meaſure ſolve the ſeeming Difficulty of the Woman's being unhurt between the two Perſons that were kill'd.

3.] At *Colcheſter*, on *July* 16, 1708. about Eight of the Clock at Night (the greater Part of the Afternoon being cloudy, but more thick toward Night, with Thunder at a Diſtance for above an Hour before, and much Lightning) I heard a Thunder-Crack ſo loud, as if it were cloſe to me, (the like I never heard before;) at which Time the Thunder and Lightning broke into Mr. *King*'s Houſe, beginning at the South-ſide thereof, at the Gable-end, breaking ſeveral Roof-Tiles, and near 20 other, as at *c* in the *Figure*, continuing its Courſe perpendicular, and in a ſtraight Line (the only Motion that ſeems conſiſtent with ſuch Violence, which, it ſeems, was otherwiſe in the Gentlewoman's Houſe in *Ireland*) it went into a Lean-to, and lighting on a bunching out of the Wall at *d*, it enter'd into the Strong-Beer Buttery through the Laths, and forced a Cork out of the lower Tap-hole of a But: In its Way at *a*, it ſhiver'd a Stud about three Inches ſquare, ſo that one Side remain'd nail'd to Laths, yet not much thicker than a Lath, and alſo brake it in two, as if it were a Tobacco-pipe. Below the Beam at *b*, it clave

——*at* Colcheſter *on the* ſame Day, *by Mr.* J. Nelſon. *ibid.*

Fig. 20.

clave or ſplit a Stud, about four Inches ſquare, ſeveral Foot down, which is there ſtanding; this was from its violent razing on the outſide. At the Time of this Blow, Mr. *King* was in the Lean-to, but receiv'd no Hurt; he ſmell'd a ſtrong ſulphureous Scent. It caſt the broken Wall divers Rood with the Violence. There was ſome little Damage done to *Alhallows* Church about the ſame Time in the ſaid Town.

Divers Boats were carrying Perſons from *Harwich* to *Ipſwich* on the *Orwell*; the Violence of the Thunder and Lightning kill'd four dead immediately, made a Lad run mad, and wounded the reſt that were in that Boat, which were twelve Perſons, and melted a Watch and the Chain all of a Lump which was in a dead Man's Pocket; this was about the ſame Time of the aforemention'd. Mr. *Thomas Holborow* of *Colcheſter*, was Eye-witneſs to this: Being in one of the Boats, he ſmell'd ſuch a Scent of Sulphur, as he could not bear. This was about eighteen Miles N. E. of *Colcheſter*, and one Mile S. E. it was no more violent than an ordinary Storm.

——*in* Yorkſhire; *with violent* Rain; *by Mr.* R. Thoresby. n. 319. p. 289.

4.] On the *5th* Day of *July* 1708, we had *a Storm of Thunder, Lightning, and violent Rain*; I was then at the *Spaw* at *Harrow-gate*, near *Knaresborough*; where having a ſpacious View upon the open Foreſt, I obſerv'd the Motion of the Clouds and Storm, which began in the Weſt, wheel'd about by the North and Eaſt to the South. When the Night drew on, the Lightning appear'd more dreadful. The Intermiſſion betwixt the Flaſhes was very ſmall; the Claps of Thunder were very loud, and the Flaſhes of Lightning were continu'd. The Reverend Mr. *Furnis* of *Bewerly* writes, that *Thomas Horner*, with others, flying from the Violence of the Rain, which ſeem'd rather to fall in *Spouts* than Drops, took ſhelter in a neighbouring Barn, whence, after ſeveral frightful Thunder-claps, they were expell'd by the *Bolt*, as they term'd it, but really the Lightning, which ſinged the Hair of the ſaid *Horner*, blew another Man backward, who was climbing up the Hay-Mow, left a ſulphureous Stench behind it, and burnt the Barn and Hay. The *Inundation* of Rain was ſurprizing; it tore up much of the Road and Street, from the Church to the Bridge, and made Pits in ſome Places, ſeveral Yards deep, threw down part of a Barn and a Stable, both of them lately built; it puſh'd into moſt of the Houſes in the Town; the Water, in ſome, was as high as the Soals of the Windows, and block'd up the Door of one Houſe with Gravel, almoſt to the very Top. Several Perſons were in great Danger, but only one Woman drown'd: She was hurry'd away with the Violence of the Stream, and not found till the fourth Day after. It removed the Bole of a large Oak ſeveral Yards; bore down the moſt Part of four Wood Bridges, and has left at the End of the great Stone Bridge,

or

or within about 100 Yards of it, as much Gravel, &c. as is computed at above a thouſand Cart Loads. For all this Deluge, the River *Nidd* kept within Bounds.

5.] We had much Thunder and Lightning in *Yorkſhire*, on the 12*th* of *December* 1710, in the Morning. The Lightning was ſo ſevere, that one *Sainor* a Gardiner, as he was riding over *Bramham-moor*, thought his Hair had been burnt, and his Face ſcorch'd at one Flaſh, which being more ſevere than the reſt, did actually ſet on Fire the Stick he had in his Hand, as he was ready to depoſe upon Oath before the Mayor of *Leeds*, who preſented me with the ſaid Hazle Rod, which the Gardiner had given him. It yet retains Part of the Blackneſs, tho' the Man (little minding it as a Curioſity) had beat off much of the End of the Rod in forcing his Horſe forward.

— *in* Yorkſhire, *by the* ſame, n. 331. p. 321.

6.] At *Sampford Courtney* in *Devonſhire*, on the 7*th* of *October* 1711, in the Afternoon, when the Miniſter was officiating (from whom I have this Account) there was ſo great a Darkneſs, that he could hardly ſee with Spectacles: As ſoon as Prayers were over, ſome Men went to ringing, and ſeveral others were talking in the Church-Porch; a great Fire-Ball, on a ſudden, fell in between them, and threw ſome one way, ſome another, but no one received any Hurt: The Ringers ſaid they never knew the Bells go ſo heavy, and were forc'd to leave off: And being very weary, and looking out of the Belfrey into the Church, ſaw four Fire-Balls a little bigger than a Man's Fiſt, which of a ſudden broke to Pieces, ſo that the Church was full of Fire and Smoak.

John Goodman's Man receiv'd a full Blow in the Neck, which made him bleed both at the Noſe and Mouth; but he is very well now. He ſays, that the Fire and Smoke went up into the Tower, which broke a great Beam on which one of the Bells hung, which fell down on the Floor. It likewiſe carried away one of the Pinnacles of the Tower next the Town, and threw ſome of the Stones near a Barn-Door at a pretty Diſtance from the Church, and has done ſome Damage to the Barn at one End. The Chimney of the Houſe was remov'd in ſuch a manner, by the Thunder and Lightning, that all People admir'd that it ſtood, and did not fall upon the Houſe. Tho' the People ran about in great Conſternation, no one was hurt.

— *in* Devonſhire, *communicated by Mr.* J. Chamberlayne, n. 336. p. 528.

XIX. I have collected what I can remember, relating to a *Meteor* I ſaw in *Jamaica* about the Year 1700. As I was riding one Morning from my Habitation ſituated about three Miles North-Weſt from *St. Jago de la Vega*; I ſaw a Ball of Fire, appearing to me

A Fiery Meteor, &c. *in* Jamaica, *by Mr.* H. Barham, n. 357. p. 837.

me of the Bigneſs of a Bomb, ſwiftly falling down with a great Blaze. As I thought it fell into the Town; but when I came within a Quarter of a Mile of the Town, I ſaw many People gather'd together a little to the Southern in the *Savanna*, to whom I rode up, where they were admiring at the Ground's being ſtrangely broke and plough'd in by a Ball of Fire, which, as they ſaid, fell down there. I obſerv'd there were many Holes in the Ground, one in the middle of the Bigneſs of a Man's Skull, and five or ſix ſmaller Holes round about it, of the Bigneſs of a Man's Fiſt, and ſo deep (eſpecially the biggeſt) as not to be fathom'd by what long Switches or Sticks they had at Hand. I did not hear that any was ſo curious as to make any farther Search: It was obſerv'd, that the green Graſs was perfectly burnt near the Holes, and a ſtrong Smell of Sulphur remain'd thereabouts for a good while after.

Note, that we had a terrible rainy Night before, with much Lightning and great Thunder-Claps, which we have very frequently in *Jamaica*, often killing Cattle in the Fields. Mr. *Henry Lord*, who lives at *Dry-River*, had two Sons ſtruck dead with Lightning, in 1716, without any Wounds or Appearance of Hurt found about them. And as theſe Claps are much louder and ſtronger than any I ever heard in *Europe*, ſo are our Showers of Rain, pouring down in a moſt violent Manner. We have Lightning all the Year round, but our great Rains are in the Months of *May*, *Auguſt*, and *October*. I knew *May* for two or three Years without Rain, which was look'd upon as a great Wonder: And we paid dear for it in our *Indigo:* For a Catterpillar appear'd and wove a fine Silk about the *Indigo-Plant*, and deſtroy'd it all, hurting nothing elſe. *May*-Rains uſed to deſtroy theſe Worms. *Auguſt* and *October* never go out without a Flood, we having then univerſal Rains all over the Iſland, coming from the Sea: For we have often Rains in the Mountains from the Clouds lodging there, when we have none in the Lowlands.

Our Iſland is full of Mines, and, if ſearch'd into, I queſtion not but very rich. We are very ſubject to Earthquakes, ſeveral happening every Year, eſpecially after great Rains, which fill up all our great Cracks in the Surface of the Earth: For in a very dry Time, we have them ſo very large, deep, and gaping ſo open and wide, that it is dangerous to ride over ſome Parts of the *Savannaes*, for Fear a Horſe ſhould get his Legs into them. Our Earthquakes make a Noiſe or Rumbling in the Earth, before we feel the Shake; and ſeem to run ſwiftly to the Weſtward.

A Lunar Rain-Bow *ſeen in* Derbyſhire, *by*——*communicated by Mr.* R. Thoreſby n. 331. p. 320.

XX. A Gentleman of great Veracity told me, he had ſeen a *Lunar Rain-Bow* in *Derbyſhire* on *Chriſtmas* 1710. That walking towards

wards *Patterton Green*, about eight in the Evening, he obſerv'd with great Satisfaction the Bow, which the Moon had fix'd in the Clouds: She had then paſs'd her Full about 24 Hours, the Evening had been rainy, but the Clouds were diſpers'd, and the Moon ſhin'd pretty clear. This *Iris* was more remarkable than that which Dr. *Plot* obſerv'd at *Oxford*, the 23*d* of *November* 1675, that being only of a white Colour, but this had all the Colours of the *Iris Solaris*, exceeding pleaſant, diſtinct, and grateful to look upon; only faint, comparatively to thoſe we ſee in the Day; as muſt neceſſarily follow, both from the different Beams that cauſe it, and the Diſpoſition of the Medium. What puzzled him the moſt was the Largeneſs of the Arc, which was not ſo much leſs than that of the Sun, as the different Dimenſions of their Bodies, and their reſpective Diſtances from the Earth, ſeem to require: But as to its Entireneſs, and Beauty of its Colour, it was admirable and ſurprizing. It continu'd about ten Minutes, before the Interpoſition of a Cloud hinder'd his further Obſervation.

A Glade of Light ſeen in the Heavens, by Mr. W. Derham. n. 305. p. 2220.

XXI. As I was obſerving the Immerſions of the third and fourth Satellite of *Saturn* on the 20*th* of *March* 170$\frac{5}{6}$, in the Evening; I eſpy'd a very odd ſort of Light in the Conſtellation of *Taurus*, the lower End of which was below the Bull's Eye, and the other a good Way above it, and that Star about the middle of the lower End thereof (as in *Fig.* 21.) which repreſents its Appearance to me. This Glade of Light had the ſame Motion that the Heavens had, and was much like the Tail of a Comet, but pointed at the upper End. This Light, I doubt not, is ſuch as Dr. *Childrey* firſt obſerv'd in *England*; and *Caſſini*, and others afterwards in *France*.

Fig. 21.

A Pyramidal Appearance in the Heavens ſeen in Eſſex, by Mr. W. Derham. n. 310. p. 2411.

XXII. On *Thurſday*, *April* 3. 1707, I perceived in the Weſtern Part of the Heavens, about a Quarter of an Hour after Sun-ſet, a long ſlender *Pyramidal Appearance*, perpendicular to the Horizon. The *Baſe* of this *Pyramid*, I judged to be the Sun (then below the Horizon.) Its *Apex* reach'd 15 or 20 Degrees above the Horizon. It was throughout of a ruſty red Colour; and when I firſt ſaw it, pretty vivid and ſtrong; but the Top-part fainter much than the Bottom, nearer the Horizon. At what time this Appearance began, whether at, or how ſoon after Sun-ſet, I cannot ſay. But about a Quarter of an Hour after Sun-ſet I perceiv'd it, and had, for ſome time, a fair Proſpect of it, the Horizon being pretty free and open where I then was. But after a while, it grew by Degrees weaker and weaker, ſo that in about a Quarter of an Hour after I firſt ſaw it, the Top-part (*a. b. d.*) was ſcarce viſible. But the Lower-part remain'd vivid much longer; but yet grew by De-

Fig. 22.

grees ſhorter and ſhorter. I ſaw the Remains of the lower half *(b. d. e. f.)* a full Hour after Sun-ſet; and ſhould perhaps have ſeen it longer, had the Horizon been open. But it was often in my Walk pent up with Trees.

The whole Atmoſphere ſeem'd hazy, and full of Vapours, eſpecially towards the Sun-ſet. The Moon and Stars were that Evening bearded at that Time, and ſucceeded with an *Halo* about the Moon afterwards. Which Diſpoſition of the Air was probably the Cauſe of the Phænomenon. But the Pyramid was undoubtedly imprinted upon the far diſtant Vapours of the Atmoſphere; it being manifeſtly farther off, or lying beyond ſome ſmall thin Clouds *(C. L. c. l.)* that intercepted it, and in thoſe Parts cover'd and hid it.

I do not remember I ever ſaw any thing like it, except the white Pyramidal Glade, which is now entituled by the Name of the *Aurora Borealis*; that being (except in Colour and Length) like it.

I have ſearched every Night ſince for this *Pyramis Veſpertina*, but have not ſeen any ſuch Appearance, altho' the next Evening was hazy and likely. I alſo look'd out to ſee whether the *Aurora Borealis* would ſucceed in the Room thereof, but diſcover'd no ſuch thing.

A Meteor *in* Yorkſhire, *by Mr.* R. Thoreſby. n. 331. p. 322.

XXIII. A ſtrange Meteor was ſeen at *Leeds* 1710, on *Holy Thurſday*; the common People call'd it a Flaming Sword. It was ſeen not only in the Neighbouring Towns, but a great Way North, as alſo above fifty Miles South of *Leeds*. It appear'd here at a Quarter paſt ten at Night, and took its Courſe from South to North: It was broad at one End, and ſmall at the other; and was by ſome thought to reſemble a Trumpet, and mov'd with the broad End foremoſt: the Light was ſo bright, that People ſaw their own Shadows. I was reading (the Curtain of the Window being drawn) ſo ſaw nothing, except a ſudden Flaſh of Light. It is remarkable, that all Perſons (tho' at many Miles Diſtance from each other, when they ſaw it) thought it fell within three or four Furlongs of them, and that it went out with bright Sparklings at the ſmall End. An ingenious Clergyman told me, that it was the ſtrangeſt *Deceptio viſus* he was ever ſenſible of, if it was not abſolutely extinguiſh'd within a few Paces of him; and yet others ſaw it many Miles off, further North in a few Moments.

A ſtrange Meteor, *or* Aurora Borealis *ſeen in* Ireland, *by Mr.* Neve. n. 320. p. 310.

It has been ſeen in the Counties of *Nottingham* and *Derby*, as well as *York* and *Lancaſter*.

XXIV. 1.] On *Sunday*, *November* 16. 1707, after a Froſty Morning, and Fair ſtill Day, Wind North-Weſterly, about half an Hour

Hour after eight in the Evening, there appear'd a very ſtrange Light in the North. The Evening was clear and Star-light, only the Horizon was darken'd with condenſed Vapours in the North, reaching, as I gueſs, ten or fifteen Degrees above the Horizon. Out of this Cloud proceeded ſeveral *Streams* or *Rays* of *Light*, like the Tails of ſome Comets, broad below, and ending in Points above. Some of them extended almoſt to the Tail of *Urſa Minor*, and all were nearly perpendicular to the Horizon, and it was as bright, as if the Full Moon had been riſing in the Cloud. But what I wonder'd at moſt, was, the Motion of the dark and lighter Parts running ſtrangely through one another in a Moment; ſometimes to the Eaſt, and ſometimes to the Weſt. It continued, after I firſt ſaw it, about a Quarter of an Hour, often changing its Face and Appearance, as to Form and Light; ſometimes broken, ſometimes entire and long Rays of Light in the clear Sky, quite ſeparate from and above the Cloud, and none below in the Cloud.

2.] Much ſuch another Appearance Mr. *Barret* was credibly inform'd was ſeen in his Neighbourhood in *Eſſex*, in *September* or *October* 1706. —*by Mr.* W. Derham *ib.*

XXV. The *Theory* of the Air ſeems to be perfectly well underſtood, and the differing Denſities thereof at all Altitudes, both by Reaſon and Experiment, are ſufficiently defined: For ſuppoſing the ſame Air to occupy Spaces reciprocally proportional to the Quantity of the ſuperior or incumbent Air, I have (*) elſewhere prov'd, that at 40 Miles high, the Air is rarer than at the Surface of the Earth, about 3000 Times; and that the utmoſt Height of the Atmoſphere, which reflects Light in the *Crepuſculum*, is not fully 45 Miles: Notwithſtanding which, it is manifeſt that ſome Sort of Vapours, and thoſe in no ſmall Quantity, ariſe nearly to that Height. An Inſtance of this may be given in the great Light, (†) *September* 1676. mention'd by Dr. *Wallis*, which was ſeen in very diſtant Counties, almoſt over all the South Part of *England*. Of which, though the Doctor could not get ſo particular a Relation, as was requiſite to determine the Height thereof, yet from the diſtant Places it was ſeen in, it could not but be very many Miles high.

An Account *of ſeveral extraordinary* Meteors; *by Dr.* E. Halley. n. 341. p. 159.

(*) *Vid.* Supra V. 11. C. 1. S. IX.

(†) *Vid.* Supra, V. 11. C. 1. S. LXXI.

So likewiſe that Meteor which was ſeen in 1708, on the 31*ſt* of *July*, between nine and ten a Clock at Night, was evidently between 40 and 50 Miles perpendicularly high, and as near as I can gather, over *Sheerneſs* and the *Buoy on the Nore*. For it was ſeen at *London* moving horizontally from E. by N. to E. by S. at leaſt 50 Degrees high; and at *Redgrave* in *Suffolk*, on the *Yarmouth* Road, about 20 Miles from the Eaſt Coaſt of *England*, and at leaſt 40 Miles to the Eaſtward of *London*, it appear'd a little to the Weſtward of the

South, ſuppoſe S. by W. and was ſeen about 30 Degrees high, ſliding obliquely downwards. We may conclude, that it was not many Miles more Weſterly than *Redgrave*, which is above 40 Miles more Eaſterly than *London*. Suppoſe it, therefore, where perpendicular, to have been 35 Miles Eaſt from *London*, and by the Altitude it appear'd at in *London*, *viz.* 50 Degrees, its Tangent will be 42 Miles; for the Height of the Meteor above the Surface of the Earth, which alſo is rather of the leaſt, becauſe the Altitude of the Place ſhewn me, is rather more than leſs than 50 Degrees: And the ſame may be concluded from the Altitude it appear'd in at *Redgrave*, near 70 Miles diſtant. Though at this great Diſtance it appear'd to move with an incredible Velocity, darting, in a very few Seconds of Time, for about 12 Degrees of a great Circle from North to South, being very bright at its firſt Appearance; and it died away at the End of its Courſe, leaving for ſome Time a pale Whiteneſs in the Place, with ſome Remains of it in the Track where it had gone; but no hiſſing Sound as it paſs'd, or Bounce of an Exploſion, were heard.

It may deſerve Enquiry, how ſo great a Quantity of Vapour ſhould be raiſed to the very Top of the Atmoſphere, and there collected, ſo as upon its Accenſion, or otherwiſe Illumination, to give a Light to a Circle of above 100 Miles Diameter, not much inferior to the Light of the Moon. 'Tis hard to conceive what ſort of Exhalations ſhould riſe from the Earth, either by the Action of the Sun, or ſubterranean Heat, ſo as to ſurmount the extreme Cold and Rareneſs of the Air in thoſe upper Regions.

Like to this, but much more conſiderable, was that famous Meteor which was ſeen to paſs over *Italy* on the 21*ſt* of *March O. S. Anno* 1676, about an Hour and three Quarters after Sun-ſet, which happen'd to be obſerv'd by the famous Profeſſor of Mathematicks in *Bononia Geminian Montanari*, as may be ſeen in his *Italian* Treatiſe. He obſerves that at *Bononia*, its greateſt Altitude in the S. S. E. was 38 Degrees, and at *Siena* 58 to the N. N. W. that its Courſe by the Concurrence of all the Obſervers, was from E. N. E. to W. S. W. that it came over the *Adriatick* Sea, as from *Dalmatia:* That it croſs'd over all *Italy*, being nearly vertical to *Rimini* and *Savigniano* on the one Side, and to *Leghorne* on the other: That its perpendicular Altitude was at leaſt 38 Miles: That in all Places near this Courſe, it was heard to make a hiſſing Noiſe, *Ronzare*, *Far ſtrepito comme un fuoco artificiale*, *Fiſciare per aria comme un Ragio di polve*; that having paſs'd over *Leghorn*, it went off to Sea towards *Corſica*; and laſtly, that at *Leghorn*, it was heard to give a very great Blow, *Tuono di maggior rumore di groſſa Cannonata*; immediately after which, another ſort of Sound was heard, like the rattling of a great Cart running over Stones, which continued about the Time of a *Credo*.

He

He concludes, from the apparent Velocity it went on with at *Bononia*, at above 50 Miles Diſtance, that it could not be leſs ſwift than 160 Miles in a Minute of Time. To this he adds the Magnitude thereof, which appear'd at *Bononia* bigger than the Moon in one Diameter, and above half as big again in the other; which with the given Diſtance of the Eye, makes its real leſſer Diameter above half a Mile, and the other in Proportion. This ſuppoſed, it cannot be wonder'd that ſo great a Body moving with ſuch an incredible Velocity through the Air, though ſo much rarified as it is in its upper Regions, ſhould occaſion ſo great a hiſſing Noiſe, as to be heard at ſuch a Diſtance as this was. But 'twill be much harder to conceive, how ſuch an *Impetus* could be impreſs'd on the Body thereof, which by many Degrees exceeds that of any Cannon Ball; and how this *Impetus* ſhould be determined in a Direction ſo nearly parallel to the Horizon, and what ſort of Subſtance it muſt be that could be ſo impell'd and ignited at the ſame Time: There being no *Vulcano*, or other *Spiraculum* of ſubterraneous Fire in the N. E. Parts of the World, that we ever yet heard of, from whence it might be projected.

I have conſider'd this Appearance, and think it one of the hardeſt Things to account for, that I have met with in the *Phænomena* of *Meteors*, and am induc'd to think, that it muſt be ſome Collection of Matter form'd in the *Æther*, as it were by ſome fortuitous Concourſe of Atoms, and that the Earth met with it as it paſs'd along in its Orb, then but newly form'd, and before it had conceiv'd any great *Impetus* of Deſcent towards the Sun. For the Direction of it was exactly contrary to that of the Earth, which made an Angle with the Meridian at that Time (the Sun being in about 11 Degrees of *Aries*) of 67 Gr. that is, its Courſe was from W. S. W. to E. N. E. wherefore the *Meteor* ſeem'd to be mov'd the contrary Way: And beſides falling into the Power of the Earth's Gravity, and loſing its Motion from the Oppoſition of the *Medium*, it ſeems that it deſcended towards the Earth, and was extinguiſh'd in the *Tyrrhene Sea*, to the W. S. W. of *Leghorn*. The great Blow being heard upon its firſt Immerſion into the Water, and the ratling, like the driving a Cart over Stones, being what ſucceeded upon its quenching; ſomething like which, is always obſerv'd upon quenching a very hot Iron in Water.

There has fallen into my Hands an Account of much ſuch another Appearance, ſeen in *Germany*, in the Year 1686, at *Leipſick*, by the late Mr. *Gottfreid Kirch*, who, in an Appendix to his *Ephemerides* for the Year 1688, gives us this remarkable Relation in the following Words.

Die 9 Jul. ſt. vet. *Hora* 1 ½ *matutina, Globus ardens cauda præditus in* 8 ½ *Gr. Aquarii & 4 Gr. Sept. apparuit, qui per ſemiquadrantem Horæ immo-*

immotus perſtitit, cujus diameter ſemidiametrum Lunæ circiter æquabat. Primo lux tanta erat, ut ejus ope ſine candelis legere potuiſſemus: Poſtea pedetentim in loco ſuo evaneſcebat. Phænomenon iſtud dicto tempore multis aliis in locis pariter viſum eſt, præſertim Schlaizii, *oppido undecim milliaribus Germanicis abhinc (i. e. a* Lipſiâ) *verſus Meridiem diſtante, altitudine circiter 60 Gr. ab Horizonte meridiano.*

At the Time of this Appearance the Sun was in $26\frac{1}{2}$ Gr. of *Cancer*, and by the given Place of the Meteor, 'tis plain, it was ſeen about $\frac{3}{4}$ of an Hour paſt the Meridian, or in S. *by* W. and by its Declination it could not be above 24 Degrees high at *Leipſick*, though the ſame, at *Schlaize*, was about 60 Gr. high: The Angle therefore at the Meteor, was about 36 Gr. Whence, by an eaſy *Calculus*, it will be found, that the ſame was not leſs than 16 *German* Miles diſtant in a right Line from *Leipſick*, and above $6\frac{1}{2}$ ſuch Miles perpendicular above the Horizon, that is, at leaſt 30 *Engliſh* Miles high in the Air. And though he ſays of it, *immotus perſtitit per ſemiquadrantem horæ*; 'tis not to be underſtood that it kept its Place like a fix'd Star, all the Time of its Appearance; but that it had no very remarkable progreſſive Motion. For himſelf has at the End of the ſaid *Ephemerides* given a Figure of it, whereby it appears, that it darted downwards obliquely to the Right Hand, and where it ended, left two Globules or Nodes, not viſible but by an Optick Tube.

The ſame Mr. *Kirch*, in the Beginning of a *German* Treatiſe of his, concerning the great Comet which appear'd in the Year 1680, intituled, **Newe Himmels zeitung,** printed at *Nurenburg*, *Anno* 1681, gives us a Relation of ſuch another luminous Meteor ſeen likewiſe at *Leipſick*, on the 22*d* of *May* 1680, *ſt. vet.* about three in the Morning: Which, though himſelf ſaw not, was obſerv'd by divers Perſons, who made various Reports of it, but the more intelligent agreed, that it was ſeen deſcending in the North, and left behind it a long white Streak where it had paſs'd. At the ſame Time at *Haarburgh*, the like Appearance was ſeen in N. E. or rather N. N. E. as alſo at *Hamburg*, *Lubeck* and *Stralſund*, all which are about 40 *German* Miles from *Leipſick*: But in all theſe Places, by Perſons unacquainted with the Manner of properly deſcribing Things of this Kind. So that all we can conclude from it is, that this Meteor was exceeding high above the Earth, as well as the former.

All the Circumſtances of theſe *Phænomena* agree with what was ſeen in *England* in 1708.

An Account *of* Lights *ſeen in the Air*, March 6, 1715-16, *&c. by Dr.* E. Halley. n. 347. p. 406.

XXVI. 1.] The *Society* having receiv'd Accounts from many Parts of *Great Britain*, of the unuſual *Lights*, which have appear'd in the *Heavens*, deſir'd me to draw up a general Relation of the *Fact*, and to explain more at large ſome Conceptions of mine, which I had propoſed

poſed to them, relating to the Cauſe. The Account of this Appearance take as follows.

On *Tueſday* the ſixth of *March*, *ſt. vet.* in the current Year 1716, (the Afternoon having been very ſerene and calm, and ſomewhat warmer than ordinary) about the Time it began to grow dark, (much about ſeven of the Clock) not only in *London*, but in all Parts of *England*, where the Beginning of this wonderful Sight was ſeen; out of what ſeem'd a duſky Cloud, in the N. E. Parts of the Heaven, and ſcarce ten Degrees high, the Edges whereof were tinged with a reddiſh Yellow, like as if the Moon had been hid behind it, there aroſe very long luminous Rays or Streaks perpendicular to the Horizon, ſome of which ſeem'd nearly to aſcend to the Zenith. Preſently after, that reddiſh Cloud was ſwiftly propagated along the Northern Horizon into the N. W. and ſtill farther Weſterly; and immediately ſent forth its Rays from all Parts, now here, now there, they obſerving no Rule or Order in their riſing. Many of theſe Rays ſeeming to concur near the *Zenith*, formed there a *Corona*, or Image which drew the Attention of all Spectators. Some liken'd it to that Repreſentation of *Glory* wherewith our Painters in Churches ſurround the Holy *Name of God*. Others to thoſe radiating *Stars*, wherewith the Breaſts of the *Knights* of the Order of the *Garter* are adorn'd. Many compar'd it to the *Concave* of the great *Cupola* of St. *Paul*'s Church, diſtinguiſh'd with Streaks alternately light and obſcure, and having in the middle a Space leſs bright than the reſt, reſembling the Lantern. Whilſt others, to expreſs as well the Motion as Figure thereof, would have it to be like the Flame in an Oven, reverberated and rouling againſt the arched Roof thereof: Some thought it liker to that tremulous Light which is caſt againſt a Ceiling by the Beams of the Sun, reflected from the Surface of Water in a Baſon that's a little ſhaken; whoſe reciprocal vibrating Motion it very much imitated. But all agree, that this *Spectrum* laſted only a few Minutes, and exhibited itſelf variouſly tinged with Colours, Yellow, Red, and a duſky Green: Nor did it keep in the ſame Place; for when firſt it began, it appear'd a little to the Northwards of the *Zenith*, but by Degrees declining towards the South, the long *Striæ* of Light, which aroſe from all Parts of the Northern Semicircle of the Horizon, ſeem'd to meet together, not much above the Head of *Caſtor*, or the Northern *Twin*, and there ſoon diſappear'd.

After the firſt *Impetus* of this aſcending Vapour was over, the *Corona* appear'd no more; but ſtill, without any Order as to Time, or Place, or Size, luminous *Radii*, like the former, continued to ariſe perpendicularly, now oftner, and again ſeldomer; now here, now there; now longer, now ſhorter. Nor did they proceed as at firſt out of a Cloud, but oftner would emerge at once out of the

pure Sky, which was more than ordinary ſerene and ſtill. Nor were they all of the ſame Form. Moſt of them ſeem'd to end in a Point upwards, like erect Cones; others like truncate Cones or Cylinders, ſo much reſembled the long Tails of Comets, that at firſt ſight, they might well be taken for ſuch. Some of theſe Rays would continue viſible for ſeveral Minutes; when others, and thoſe the much greater Part, juſt ſhew'd themſelves, and died away. Some ſeem'd to have little Motion, and to ſtand, as it were fix'd, among the Stars, whilſt other with a very perceptible Tranſlation mov'd from Eaſt to Weſt under the Pole, contrary to the Motion of the Heavens; by which Means they would ſometimes ſeem to run together, and at other Times to fly one another.

After this Sight had continued about an Hour and a half, thoſe Beams began to riſe much fewer in Number, and not near ſo high, and by Degrees that diffuſed Light, which had illuſtrated the Northern Parts of the Hemiſphere, ſeem'd to ſubſide, and ſettling on the Horizon formed the Reſemblance of a very bright *Crepuſculum*: That this was the State of this *Phænomenon*, in the firſt Hours, is abundantly confirm'd by the unanimous Conſent of ſeveral. For, by the Letters we have receiv'd from almoſt all the extreme Parts of the Kingdom, there is found very little Difference in the Deſcription from what appear'd at *London* and *Oxford*; unleſs that in the North of *England* and in *Scotland*, the Light ſeem'd ſomewhat ſtronger and brighter.

Hitherto I have related the Obſervations of others: As to myſelf, I had no Notice of this Matter, till between nine and ten of the Clock; upon the firſt Information of the Thing, I immediately ran to the Windows, which happen'd to regard the *South* and *South-Weſt* Quarter; and ſoon perceiv'd, that though the Sky was very clear; yet it was tinged with a ſtrange ſort of Light; ſo that the ſmaller Stars were ſcarce to be ſeen, and much as it is when the Moon of four Days old appears after Twilight. I perceiv'd at the ſame Time a very thin Vapour to paſs before us, which aroſe from the preciſe *Eaſt* Part of the *Horizon*, aſcending obliquely, ſo as to leave the *Zenith* about 15 or 20 Degrees to the Northward. But the Swiftneſs wherewith it proceeded was ſcarce to be believed, ſeeming not inferior to that of Lightning; and exhibiting, as it paſs'd on, a ſort of momentaneous *Nubecula*, which diſcover'd itſelf by a very diluted and faint Whiteneſs; and was no ſooner formed, but before the Eye could well take it, it was gone, and left no Signs behind it. Nor was this a ſingle Appearance; but for ſeveral Minutes, about ſix or ſeven Times in a Minute, the ſame was again and again repeated; theſe Waves of Vapour regularly ſucceeding one another, and at Intervals very nearly equal; all of them in their Aſcent producing a like tranſient *Nubecula*.

By

By this Particular we were firſt aſſured; that the Vapour we ſaw, became conſpicuous by its own proper Light, without Help of the Sun's Beams; for theſe *Nubeculæ* did not diſcover themſelves in any other Part of their Paſſage, but only between the *South-Eaſt* and *South*, where being oppoſite to the Sun, they were deepeſt immers'd in the Cone of the Earth's Shadow; nor were they viſible before or after. Whereas the contrary muſt have happen'd, had they borrow'd their Light from the Sun.

I then made all the Haſte I could to a Place where there was a free Proſpect of the Northern Horizon. Being come there, not much paſt ten of the Clock, I found, on the Weſtern ſide, *viz.* between W. and N. W. the Repreſentation of a very bright *Twilight*, contiguous to the Horizon; out of which aroſe very long Beams of Light, not exactly erect toward the *Vertex*, but ſomething declining to the South; which aſcending by a quick and undulating Motion to a conſiderable Height, vaniſh'd in a little Time, whilſt others, tho' at uncertain Intervals, ſupply'd their Place. But at the ſame Time, through all the reſt of the Northern Horizon, *viz.* from the North-Weſt to the true Eaſt, there did not appear any Sign of Light to ariſe from, or joyn to, the Horizon; but what appear'd to be an exceeding black and diſmal Cloud ſeem'd to hang over all that Part of it. Yet was it no Cloud, but only the ſerene Sky more than ordinary pure and limpid, ſo that the bright Stars ſhone clearly in it, and particularly *Cauda Cygni*, then very low in the *North*; the great Blackneſs manifeſtly proceeding from the Neighbourhood of the Light which was collected above it. For the Light had now put on a Form quite different from all that we have been deſcribing, and had faſhion'd itſelf into the Shape of two *Laminæ* or Streaks, lying in a Poſition parallel to the Horizon, whoſe Edges were but ill terminated. They extended themſelves from the *N.* by *E.* to the *North-Eaſt*, and were each about a Degree broad; the undermoſt about eight or nine Degrees high, and the other about four or five Degrees over it; theſe kept their Places for a long Time, and made the Sky ſo light, that I believe a Man might eaſily have read an ordinary Print by the Help thereof.

Whilſt I was viewing this ſurprizing Sight, and expecting what was further to come, the Northern End of the upper *Lamina* by Degrees bent downwards, and at length cloſed with the End of the other that was under it, ſo as to ſhut up on the Northſide an intermediate Space, which ſtill continued open to the Eaſt. Not long after this, in the ſaid included Space, I ſaw a great Number of ſmall Columns or whitiſh Streaks to appear ſuddenly, erect to the Horizon, and reaching from the one *Lamina* to the other; which inſtantly diſappearing, were too quick for the Eye, ſo that I could not judge whether they aroſe from the under, or fell from the up-

per, but by their ſudden Alterations, they made ſuch an Appearance, as might well enough be taken to reſemble the Conflicts of Men in Battle.

And much about the ſame Time, there began on a ſudden to appear, low under the Pole, and very near due North, three or four lucid *Areas*, like Clouds, diſcovering themſelves, in the pure but very black Sky, by their yellowiſh Light. Theſe, as they broke out at once, ſo after they had continued a few Minutes diſappear'd as quick as if a Curtain had been drawn over them: Nor were they of any determined Figure, but both in Shape and Size might properly be compar'd to ſmall Clouds illuminated by the full Moon, but brighter.

Not long after this, from above the aforeſaid two *Laminæ*, there aroſe a very great *Pyramidal* Figure, like a *Spear*, ſharp at the Top, whoſe Sides were inclin'd to each other with an Angle of about four or five Degrees, and which ſeem'd to reach up to the *Zenith*, or beyond it. This was carried with an equable, and not very ſlow Motion, from the N. E. where it aroſe, into the N. W. where it diſappear'd, ſtill keeping in a perpendicular Situation, or very near it; and paſſing ſucceſſively over all the Stars of the *Little Bear*, did not efface the ſmaller ones in the Tail, which are but of the fifth Magnitude; ſuch was the extreme Rarity and Perſpicuity of the Matter whereof it conſiſted.

This ſingle Beam was very remarkable for its Height above all thoſe that for a great while before had preceded it, or that follow'd it.

It being now paſt eleven of the Clock, and nothing new offering itſelf to our View, but repeated *Phaſes* of the ſame Spectacle; being returned to my Houſe, I went to my upper Windows, which conveniently enough regarded the N. E. Part of the Heavens, and ſoon found that the two *Laminæ* or Streaks parallel to the Horizon, had now wholly diſappear'd; and the whole Spectacle reduced itſelf to the Reſemblance of a very bright *Crepuſculum* ſettling on the Northern Horizon, ſo as to be brighteſt and higheſt under the Pole itſelf; from whence it ſpread both Ways into the N. E. and N. W. Under this, in the middle thereof, there appear'd a very black Space, as it were the Segment of a leſſer Circle of the Sphere cut off by the Horizon. It ſeem'd to the Eye like a dark Cloud, but was not ſo; for by the Teleſcope the ſmall Stars appear'd through it more clearly than uſual, conſidering how low they were: And upon this as a *Baſis*, our *Lumen Auroriforme* reſted, which was no other than a Segment of a Ring or Zone of the Sphere, intercepted between two Parallel leſſer Circles, cut off likewiſe by the Horizon; or the Segment of a very broad *Iris*, but of one uniform Colour; *viz.* a Flame-Colour inclining to yellow, the Centre thereof being about forty

forty Degrees below the Horizon. And above this, there were ſeen ſome Rudiments of a much larger Segment, with an Interval of dark Sky between, but this was ſo exceeding faint and uncertain, that I could make no proper Eſtimate thereof.

I attended this Phænomenon till near three in the Morning, and the riſing of the Moon: But for above two Hours together, it had no manner of Change in its Appearance, nor Diminution, nor Increaſe of Light; only ſometimes, for very ſhort Intervals, as if new Fuel had been caſt on a Fire, the Light ſeem'd to undulate and ſparkle, not unlike the riſing of a vaporous Smoke out of a great Blaze, when agitated. But one Thing I aſſured my ſelf of, that this *Iris*-like Figure did by no Means owe its Origin to the Sun's Beams: For that about three in the Morning, the Sun being in the Middle between the North and Eaſt, our *Aurora* had not follow'd him, but ended in that very Point where he then was: Whereas in the true North, which the Sun had long paſs'd, the Light remain'd unchanged, and in its full Luſtre.

Thus I have endeavour'd by Words to repreſent what I ſaw; I have annexed a *Figure* exhibiting that particular Appearance of the two *Laminæ*, which I ſaw at *London* between the Hours of ten and eleven: Becauſe I do not find, among the many Relations I have ſeen, any one that has taken Notice of it. In this Figure *A B* is the under *Lamina*, ſomewhat broader and brighter than the upper *C D*: It had near its under Edge the *Lucida Lyræ*, and below its Northern Extremity, on the Left-hand, *Cauda Cygni*: And as well above and below theſe, as in the intermediate Space between them, and indeed all round about that Part of the Heavens, the Sky was ſo unuſually dark and black, as if all that *Exotic Light* that had ſhew'd itſelf before, had been then collected into thoſe two Streaks. Only at *Q*, between the Weſt and North-Weſt, and no where elſe, out of a Brightneſs adjoining to the Horizon, there aroſe conical Beams, as *M*, *L*, *N*, after the ſame Manner as at firſt. *Fig.* 23.

Whilſt we ſtood looking on, the Streak *C D*, at its Northern End, bent downward, and joined with the under *A B* at *E*, and included the Space *D C E A B*, which ſtill kept open at the other End towards the Eaſt; and in the mean Time, out of the very clear Sky, ſome luminous Spots, ſituated and figured as in the Scheme at *G*, *G*, *G*, *G*, preſented themſelves to the Eye, in Colour much like the *Laminæ*. Theſe did not ſhew themſelves all together, but came ſucceſſively, yet ſo as two or three of them were ſeen at a Time; and as their coming was inſtantaneous, ſo they went away in a Moment. At the ſame Time likewiſe, the ſeveral little white Columns mark'd *F*, *F*, *F*, *F*, occupied that Part of the Space between the two Streaks next to *E*, and by their ſudden and very irregular Motion, and the vaniſhing of ſome, whilſt others, at the ſame Time,

emerged, gave occaſion to the Conception of thoſe that fancied Battles fought in the Air. Laſtly, from about the Middle of *C D*, there aroſe ſuddenly a Cone or Obeliſk of a pale whitiſh Light, greater than any we had yet ſeen, as *H*; which moving from Eaſt to Weſt, with a Motion ſufficiently regular, was tranſlated to *K*, in the North Weſt, and there diſappear'd.

That we might by the ſame Scheme ſhew the Appearance of the laſt Hours, after Midnight; we have made the Light at ☽, much bigger than what appear'd in the Weſt about ten of the Clock; ſo as to repreſent truly that other. In this Caſe, the Point ☽ muſt, by the Imagination, be ſuppoſed transferr'd to the Interſection of the Horizon and Meridian under the Pole. The Scheme indeed could by no Means be contriv'd to anſwer the wonderful Variety this *Phænomenon* afforded; ſince even the Eye of no one ſingle Obſerver was ſufficient to follow it in the Suddenneſs and Frequency of its Alterations.

Thus I have attempted to deſcribe what was ſeen, and am ſorry I did not ſee the firſt and moſt ſurprizing Part thereof my ſelf: The like is not recorded in the *Engliſh Annals* ſince 1574, that is, above a hundred and forty Years ago, in the Reign of Queen *Elizabeth*. Then, as we are told by the Hiſtorians of thoſe Times, *Cambden* and *Stow*, for two Nights ſucceſſively, *viz.* on the 14*th* and 15*th* of *November* that Year, much the ſame wonderful *Phænomena* were ſeen, with almoſt all the ſame Circumſtances as now.

Nor, indeed, was this then ſo rare a Sight as it has been ſince: For we find, in a Book entituled, *A Deſcription of Meteors*, reprinted at *London* in the Year 1654, whoſe Author writes himſelf *W. F.* D. D. that the ſame Thing, which he there calls *Burning Spears*, was ſeen at *London* on *January* 30, 1560; and again by the Teſtimony of *Stow*, on the 7*th* of *October* 1564. And from foreign Authors we learn, that in the Year 1575, the ſame was twice repeated in *Brabant*, *viz.* on the 13*th* of *February*, and 28*th* of *September*; and ſeen and deſcribed by *Cornelius Gemma*: Who in a Diſcourſe he wrote of the Prodigies of thoſe Times, after ſeveral ill-boding Prognoſticks, thus very properly deſcribes the *Cupola* and *Corona*, that he ſaw in the *Phaſma* (as he calls it) of *February*. *Paulo poſt undecunque ſurgentibus Haſtis & flammis novis, flagrare cælum à Borea parte uſque ad verticem videbatur: Ac denique ne nihil quæ contigerunt hactenus præfiguratum antea videretur, converſa eſt Cæli facies, per horæ ſpatium, in Fritilli aleatorii ſpeciem peregrinam; alternantibus ſeſe cæruleo & candido, non minore vertigine motuſque celeritate, quam ſolares radii ſolent, quoties ab objecto ſpeculo regeruntur.* Here it is not a little remarkable, that all theſe four already mentioned, fell exactly upon the ſame Age of the Moon, *viz.* about two Days after the Change.

As

As to the other of *September* in the ſame Year 1575, theſe are the Words of *Gemma*. *Minus quidem horrendum, ſed varia tamen magiſque confuſa nobis apparuit alterius Phaſmatis forma, quarto Calendas* Octobris *ſubſecuti, ſtatim ab occaſu Solis. Nam in illo viſi ſunt arcus illuſtres plurimi, ex quibus Haſtæ ſenſim eminentes, Urbeſque turritæ & Acies militares. Erant hinc radiorum excurſus quaquaverſum, & nubium fluctus & prælia: Inſectabantur invicem & fugiebant, facta in orbem converſione mirabili.* From hence 'tis manifeſt, that this *Phænomenon* appear'd in our Neighbourhood three ſeveral Times, and that with conſiderable Intervals, within the Compaſs of one Year; though our *Engliſh* Hiſtorians have not recorded the two latter; nor did *Gemma* ſee that of *November* 1574, as 'tis moſt likely, by reaſon of Clouds. After this, in the Year 1580, we have the Authority of *Michael Maſtlin*; that at *Baknang* in the Country of *Wirtemburg* in *Germany*, theſe *Phaſmata*, as he likewiſe ſtiles them, were ſeen by himſelf no leſs than ſeven Times within the Space of twelve Months. The firſt of theſe, and moſt conſiderable, fell out on the very ſame Day of the Month with ours, *viz.* on *Sunday* the ſixth of *March*, and was attended with much the ſame Circumſtances. And again the ſame Things were ſeen in a very extraordinary Manner on the 9*th* of *April* and 10*th* of *September* following: But in a leſs Degree, on the 6*th* of *April*, 21*ſt* of *September*, 26*th* of *December*, and 16*th* of *February*, 1581. The laſt of which, and that of the 21*ſt* of *September*, muſt needs have been more conſiderable than they then appear'd, becauſe the Moon being near the Full, neceſſarily effaced all the fainter Lights. Of all theſe, however, no one is mention'd in our Annals to have been ſeen in *England*, nor in any other Place that I can find.

(*) *M.* Maſtlin *Lib. de Cometa*, 1580.

The next that we hear of, was that of the Year 1621, on *September* 2*d*, *ſt. vet.* ſeen all over *France*, and well deſcrib'd by *Gaſſendus* in his *Phyſicks*, who gives it the Name of *Aurora Borealis*. This, tho' little inferior to what we lately ſaw, and appearing to the Northwards both of *Rouen* and *Paris*, is no where ſaid to have been obſerv'd in *England*, over which the Light ſeem'd to lie.

Another was ſeen all over *Germany*, in the Year 1623, thus deſcrib'd by *Kepler*. *Die* $\frac{7}{17}$ Nov. 1623. *Meteorum ignitum, Globus ardens ab Occaſu in Ortum volans tota paſſim* Germaniâ *fuit conſpectus. In* Auſtria *etiam fragorem exauditum affirmarunt quaſi à fulmine: Quod vanum tamen puto: Nihil enim tale confirmant deſcriptiones quæ extant.*

And ſince then, for above 80 Years, we have no Account of any ſuch Sight, either from home or abroad. The firſt we find on our Books, was one of ſmall Continuance ſeen in *Ireland* by Mr. *Neve*, on the 16*th* of *November* 1707. And in the *Miſcellanea Berolinenſia*, publiſhed in 1710, we learn, that in the ſame Year 1707, both on the 24*th* of *January*, and 18*th* of *February*, *ſt. vet.* ſomething of this kind

Vid. Supra, p. 134.

kind was ſeen by Mr. *Olaus Romer* at *Copenhagen*, and again on the 23*d* of *February*, the ſame *Aſtronomer* obſerv'd there ſuch another Appearance, but much more conſiderable; of which yet he only ſaw the Beginning, Clouds interpoſing. But the ſame was ſeen that Night by Mr. *Gotfried Kirch*, at *Berlin*, above 200 Miles from *Copenhagen*, and laſted there till paſt ten at Night. To theſe add another ſmall one of ſmall Duration, ſeen near *London*, a little before Midnight between the ninth and tenth of *Auguſt* 1708, by the Lord Biſhop of *Hereford*; ſo that, it ſeems, in little more than eighteen Months, this ſort of Light has been ſeen in the Sky, no leſs than five Times in the Years 1707 and 1708.

Hence we may reaſonably conclude, that the Air, or Earth, or both, are ſometimes, though but ſeldom, and with great Intervals, diſpoſed to produce this *Phænomenon*: For though it be probable that many Times, when it happens, it may not be obſerv'd, as falling out in the Day-time, or in cloudy Weather, or bright Moonſhine: Yet, that it ſhould be ſo very often ſeen at ſome Times, and ſo ſeldom at others, is what cannot well be that Way accounted for. Wherefore conſidering what might be moſt probably the *Material Cauſe* of theſe Appearances; what firſt occurr'd was the Vapour of Water rarified exceedingly by ſubterraneous Fire, and tinged with ſulphureous Streams; which Vapour is now generally taken by our Naturaliſts to be the Cauſe of *Earthquakes*. And as Earthquakes happen with great Uncertainty, and have been ſometimes frequent in Places, where, for many Years before and after, they have not been felt; ſo theſe, which we might be allow'd to ſuppoſe produc'd by the Eruption of the pent-up Vapour through the Pores of the Earth, when it is not in ſufficient Quantity, nor ſudden enough to ſhake its Surface, or to open it ſelf a Paſſage by rending it. And as theſe Vapours are ſuddenly produc'd by the Fall of Water upon the Nitro-ſulphureous Fires under Ground, they might well be thought to get from thence a Tincture which might diſpoſe them to ſhine in the Night, and a Tendency contrary to that of Gravity; as we find the Vapours of *Gunpowder*, when heated in *Vacuo*, to ſhine in the Dark, and aſcend to the Top of the Receiver, though exhauſted: The Experiment of which, I ſaw very neatly performed by Mr. *J. Whiteſide*.

Nor ſhould I ſeek for any other Cauſe than this, if in ſome of theſe Inſtances, particularly this whereof we treat, the Appearance had not been ſeen over a much greater Part of the Earth's Surface than can be thus accounted for. It having in this laſt been viſible from the Weſt Side of *Ireland*, to the Confines of *Ruſſia* and *Poland* on the Eaſt (nor do we yet know its Limits on that Side) extending over at leaſt thirty Degrees of Longitude; and in Latitude, from about fifty Degrees over almoſt all the North of *Europe*; and in all Places

Places exhibiting at the ſame Time the ſame wondrous Circumſtances as we are informed by the Publick News. Now this is a Space much too wide to be ſhaken at any one Time by the greateſt of Earthquakes, or to be affected by the Perſpiration of that Vapour, which being included, and wanting vent, might have occaſion'd the Earth to tremble. Nor can we this Way account for that remarkable Particular attending theſe Lights, of being always ſeen on the North-ſide of the Horizon, and never to the South.

Wherefore laying aſide the explaining theſe Things by the ordinary Vapours or Exhalations of the Earth or Waters, we are forc'd to have Recourſe to other ſorts of *Effluvia* of a much more ſubtile Nature, and which perhaps may ſeem more adapted to bring about theſe wonderful and ſurprizingly quick Motions. Such are the *Magnetical Effluvia*, whoſe Atoms freely permeate the Pores of the moſt ſolid Bodies, meeting with no Obſtacles from the Interpoſition of Glaſs or Marble or even Gold itſelf. Theſe by a perpetual Efflux do, ſome of them, ariſe from the Parts near the Poles of the Magnet, whilſt others of the like Kind of Atoms, but with a contrary Tendency, enter in at the ſame Parts of the Stone, through which they freely paſs; and by a kind of Circulation ſurround it on all Sides, as with an Atmoſphere, to the Diſtance of ſome Diameters of the Body.

That the Fact may be the better comprehended, I ſhall endeavour to exhibit the Manner of the Circulation of the Atoms concern'd therein, as they are expos'd to View, by placing the Poles of a *Terella*, or *Spherical Magnet*, on a Plane, as the Globe on the Horizon of a right Sphere: Then ſtrewing fine Steel Duſt or Filings very thin on the Plane all round it, the Particles of Steel, upon a continued gentle knocking on the underſide of the Plane, will by Degrees conform themſelves to the Figures in which the Circulation is perform'd. Thus, let *A B C D* be a *Terella*, and its Poles *A* the South, and *B* the North; and by doing as preſcrib'd, it will be found that the Filings will lie in a Right Line perpendicular to the Surface of the Ball, when in the Line of the Magnetical Axis continued. But for about forty five Degrees on either Side, from *B* to *G* or *I*, and from *A* to *H* or *K*, they will form themſelves into Curves, more and more crooked as they are remoter from the Poles; and withal more and more oblique to the Surface of the Stone. Hence it may appear how this exceeding ſubtile Matter revolves; and particularly how it permeates the Magnet with more Force, and in greater Quantity in the circumpolar Parts, entering into it on the one Side, and emerging from it on the other, under the ſame oblique Angles: Whilſt in the middle Zone about *C* and *D*, near the Magnet's Equator (if I may uſe the Word) very few, if any of theſe Particles do impinge, and thoſe very obliquely. *Fig.* 24.

Now

Now by many and very evident Arguments it appears, that our *Globe* of *Earth* is no other than one great Magnet, or (if I may be allow'd to alledge an Invention of my own) rather two; the one including the other, as the *Shell* includes the *Kernel*; for ſo and not otherwiſe, we may explain the Changes of the Variation of the Magnetical Needle. It ſuffices that we may ſupport the ſame ſort of Circulation of ſuch an exceeding fine Matter to be perpetually performed in the *Earth*, as we obſerve in the *Terella*; which ſubtile Matter freely pervading the Pores of the Earth, and entering into it near its Southern Pole, may paſs out again into the *Æther*, at the ſame Diſtance from the Northern, and with a like Force; its Direction being ſtill more and more oblique, as the Diſtance from the Poles is greater. To this we beg Leave to ſuppoſe, that this ſubtile Mattle, no otherways diſcovering itſelf, but by its Effects on the Magnetic Needle, wholly imperceptible, and at other Times inviſible, may now and then, by the Concourſe of ſeveral Cauſes very rarely coincident, and to us as yet unknown, be capable of producing a ſmall Degree of Light; perhaps from the greater Denſity of the Matter, or the greater Velocity of its Motion: After the ſame Manner as we ſee the *Effluvia* of *Electrick* Bodies by a ſtrong and quick Friction emit Light in the Dark: To which ſort of Light this ſeems to have a great Affinity.

This being allow'd me, I think we may aſſign a Cauſe for many of theſe ſtrange Appearances, and for ſome of the moſt difficult to account for otherwiſe; as why theſe Lights are rarely ſeen any where elſe but in the North, and never, that we hear of, near the Equator: As alſo why they are more frequently ſeen in *Iceland* and *Greenland*, than in *Norway*, though nearer the *Pole* of the *World*. For the Magnetical Poles, in this Age, are to the Weſtward of our Meridian, and more ſo of that of *Norway*, and not far from *Greenland*; as appears by the Variation of the Needle this Year obſerv'd, full twelve Degrees at *London* to the Weſt.

The erect Poſition of the luminous Beams or *Striæ* ſo often repeated that Night, was occaſioned by the riſing of the Vapour or lucid Matter nearly perpendicular to the Earth's Surface. For that any Line erected perpendicularly upon the Surface of the Globe, will appear erect to the Horizon of an Eye placed any where in the ſame ſpherical Superficies; as *Euclid* demonſtrates in a Plane, that any Line erected at Right Angles to it, will appear to be perpendicular to that Plane from any Point thereof. That it ſhould be ſo in the Sphere, is a pretty Propoſition, not very obvious, but demonſtrated from *Prop.* 5. *Lib.* 1. *Theodoſii Sphæric.* For by it all Lines erect on the Surface paſs through the Centre, where meeting with thoſe from the Eye, they form the Planes of Vertical Circles thereto. And by the Converſe hereof, it is evident, that this luminous Matter

Matter aroſe nearly perpendicular to the Earth's Surface, becauſe it appear'd in this erect Poſition. And whereas in this Appearance, thoſe Beams which aroſe near the Eaſt and Weſt, as *L*, *M*, *N*, were furtheſt from the Perpendicular, on both Sides inclining towards the South, whilſt thoſe in the North were directly upright: The Cauſe thereof may well be explain'd by the Obliquity of the Magnetical Curves, making ſtill obtuſer Angles with the Meridians of the *Terrella*, as they are further from the Poles.

Hence alſo it is manifeſt, how that wonderful *Corona* that was ſeen to the Southwards of the *Vertex*, in the Beginning of the Night, and ſo very remarkable for its tremulous and vibrating Light, was produced; to wit, by the Concourſe of many of thoſe Beams ariſing very high out of the circumjacent Regions, and meeting near the Zenith: The *Effluvia* whereof they conſiſted mixing and interfering one with another, and thereby occaſioning a much ſtronger, but uncertain wavering Light. And ſince it is agreed by all Accounts that this *Corona* was tinged with various Colours, 'tis more than probable, that theſe Vapours were carried up to ſuch a Height, as to emerge out of the Shadow of the Earth, and to be illuſtrated by the direct Beams of the Sun: Whence it might come to paſs that this firſt *Corona* was ſeen colour'd and much brighter than what appear'd afterwards in ſome Places, where the Sight thereof was gone down much lower under the Horizon. Hence too it will be eaſily underſtood that this *Corona* was not one and the ſame in all Places, but was different in every differing Horizon; exactly after the ſame Manner as the Rainbow ſeen in the ſame Cloud is not the ſame Bow, but different to every ſeveral Eye.

Nor is it to be doubted, but the Pyramidical Figure of theſe aſcending Beams is Optical: Since, according to all likelihood, they are parallel-ſided, or rather tapering the other Way. But by the Rules of Perſpective, their Sides ought to converge to a Point, as we ſee in Paintings the Parallel Borders of ſtreight Walks, and all other Lines parallel to the Axis of Viſion, meet as in a Centre. Wherefore thoſe Rays which aroſe higheſt above the Earth, and were neareſt the Eye, ſeem'd to terminate in Cuſps ſufficiently acute, and have been for that Reaſon ſuppos'd to repreſent *Spears*. Others ſeen from afar, and perhaps not riſing ſo high as the former, would terminate, as if cut off with Planes parallel to the Horizon, like truncate Cones or Cylinders: Theſe have been taken to look like the Battlements and Towers on the Walls of Cities fortified after the ancient Manner. Whilſt others yet further off, by Reaſon of their great Diſtance, good Part of them being intercepted by the Interpoſition of the Convexity of the Earth, would only ſhew their pointed Tops, and becauſe of their Shortneſs have gotten the Name of *Swords*.

Next the Motion of theſe Beams furniſhes us with a new and moſt evident Argument to prove the diurnal Rotation of the Earth. For thoſe Beams which roſe up to a Point, and did not preſently diſappear, but continued for ſome Time, had moſt of them a ſenſible Motion from Eaſt to Weſt, contrary to that of the Heavens; the biggeſt and talleſt of them, as being neareſt, ſwifteſt; and the more remote and ſhorter, ſlower. By which Means, the one overtaking the other, they would ſometimes ſeem to meet and joſtle; and at other Times to ſeparate, and fly one another. But this Motion was only Optical, and occaſion'd by the Eye of the Spectator being carried away with Earth into the Eaſt; whilſt the exceeding rare Vapour of which thoſe Beams did conſiſt, being raiſed far above the Atmoſphere, was either wholly left behind, or elſe follow'd but with Part of its Velocity, and therefore could not but ſeem to recede and move the contrary Way. And after the ſame Manner as the Stars that go near the Zenith, paſs over thoſe Vertical Circles which border on the Meridian, much ſwifter than thoſe Stars which are more diſtant therefrom; ſo theſe luminous Rays would ſeem to recede faſter from Eaſt to Weſt, as their Baſes were nearer the Eye of the Spectator; and *è contra*, ſlower as they were further off.

Nor are we to think it ſtrange, if after ſo great a Quantity of luminous Vapour had been carried up into the *Æther* out of the Pores of the Earth, the Cauſe of its Effervеſcence at length abating, or perhaps the Matter thereof conſumed; theſe *Effluvia* ſhould at length ſubſide, and form thoſe two bright *Laminæ* which we have deſcrib'd, and whoſe Edges being turn'd to us, were capable to emit ſo much Light. I choſe to call them *Laminæ*, becauſe, without Doubt, tho' they were but thin, they ſpread Horizontally over a large Tract of the Earth's Surface. And whilſt this luminous Matter dropp'd down from the upper Plate to the under, the many little white Columns were formed between them by its Deſcent, only viſible for the Moment of their Fall. Theſe by the Swiftneſs with which they vaniſh'd, and their great Number, ſhewing themſelves, and diſappearing without any Order, exhibited a very odd Appearance; thoſe on the Right ſeeming ſometimes to drive and puſh thoſe on the left, and *vice verſa*.

I have omitted ſeveral Particulars of leſs Moment: But theſe are the principal *Phænomena*; of whoſe Cauſes I ſhould have with more Certainty given my Thoughts, if I had ſeen the whole from Beginning to End; and could have added my own Remarks to the Relations of others; and eſpecially, if we could by any Means have come at the Diſtances thereof. If it ſhall by any be thought a hard Suppoſition that I aſſume the *Effluvia* of the Magnetical Matter for this Purpoſe, which in certain Caſes may themſelves become lumi-

luminous, or rather may ſometimes carry with them out of the Bowels of the Earth, a ſort of Atoms proper to produce Light in the *Æther*. I anſwer, that we are not as yet acquainted with any other Kinds of *Effluvia* of terreſtrial Matter, which may ſerve for our Purpoſe, than thoſe we have here conſider'd, *viz.* the magnetical Atoms, and thoſe of Water highly rarified into Vapour. Nor do we find any Thing like it in what we ſee of the celeſtial Bodies, unleſs it be the *Effluvia* projected out of the Bodies of Comets to a vaſt Height, and which ſeem by a *Vis centrifuga* to fly with an incredible Swiftneſs the Centers both of the Sun and Comet, and to go off into Tails of a ſcarce conceivable Length. What may be the Conſtitution of theſe Cometical Vapours, we Inhabitants of the *Earth* can know but little, and only that they are evidently excited by the Heat of the Sun; whereas this Meteor ſeldom is ſeen but in the Polar Regions of the World, and that moſt commonly in the Winter Months.

I beg Leave on this Occaſion, to mention what, near 25 Years ſince, I publiſh'd in No. 195 (†) of theſe *Tranſactions*, *viz.* That ſuppoſing the *Earth* to be concave, with a leſſer Globe included, in order to make that inner Globe capable of being inhabited, there might not improbably be contain'd ſome luminous *Medium* between the Balls, ſo as to make a perpetual Day below. That very great Tracts of the Ætherial Space are occupied by ſuch a ſhining *Medium*, is evident from former Inſtances (*). And if ſuch a *Medium* ſhould be thus incloſed within us, what ſhould hinder but that we may ſuppoſe that ſome Parts of this lucid Subſtance may, on very rare and extraordinary Occaſions, tranſude through and penetrate the *Cortex* of our *Earth*, and being got looſe, may afford the Matter whereof this our *Meteor* conſiſts. This ſeems favour'd by one conſiderable Circumſtance, *viz.* that the *Earth*, becauſe of its diurnal Rotation, being neceſſarily of the Figure of a flat *Spheroid*, the Thickneſs of the *Cortex*, in the *Polar* Parts of the Globe, is conſiderably leſs than towards the *Equator*; and therefore more likely to give Paſſage to theſe Vapours: Whence a Reaſon may be given why theſe Lights are always ſeen in the North.

Vid. Supra, V. II. C. IV. p. 615.

(*) *Vid. Supra*, C. III. S. V.

2.] At *Paris*, the Light was ſo inconſiderable, that it was not regarded: But a Letter to Mr. *Alexander Geekie*, Surgeon, dated on Board a Ship in *Nevis* Road in *America*, *April* 19, 1716, informs us, "That on the ſixth of *March*, at Nine a Clock in the Evening, "we being then in the Latitude of 45°. 36'. (off of the N. W. "Coaſt of *Spain*); A clear Cloud appear'd Eaſt to us, not far "diſtant from our Zenith, which afterwards darted it ſelf forth in- "to a Number of Rays of Light, every way like the Tail of a "Comet, of ſuch a great Length, that it reach'd within a ſhort

A Deſcription of the ſame Phænomenon ſeen on the Ocean. n. 348. p. 430.

" Way of the Horizon. There likewiſe appear'd a Body of Light,
" N. N. E. of us, and continued as Light almoſt as Day, till after
" 12 a Clock. It appear'd at a good Diſtance from us, and darken'd
" on a ſudden.

Hence it ſhould ſeem, that the Vapour which cauſed this Appearance, aroſe indifferently out of the deep Ocean Sea, as well as from the Land; by which we may conclude the great Subtilty of the Matter thereof, ſince it could permeate ſo great a Quantity of Water, and yet retain its Velocity.

A return of the ſame, *ibid.*

3.] Since this, moſt of the ſame *Phænomena* have been repeated three ſeveral Nights ſucceſſively, *viz.* on the laſt of *March*, and firſt and ſecond of *April*. The beſt and fulleſt Deſcription of the two firſt, is, from a Letter of Dr. *B. Taylor*, dated *April* 2, from *Cotterſtock*, near *Oundle* in *Northamptonſhire*, who thus deſcribes them. " On *Saturday*
" Night laſt, and laſt Night, I ſaw Appearances of the ſame Kind,
" with thoſe of *March* 6, but not to compare for Extent and Strength.
" They both began ſoon after Sun-ſet, and continu'd till after 12, but
" how much longer, I cannot tell. They were both about 10 or 15
" Degrees to the Weſtward of the North, and took up about 80 De-
" grees of the Horizon; and the *Aurora* roſe about 30 gr. high, with
" a dark Bottom, like what was ſeen in the firſt; and from whence
" there ſprung out ſeveral Bodies of Light, which immediately ran in-
" to Streams, aſcending about 30, or at moſt 40 gr. high. There
" was no flaſhing nor waving Light, but, in all other Reſpects, theſe
" Lights were of the ſame Kind with what we ſaw at *London*. Indeed
" in that laſt Night, there was one *Phænomenon* like the flaſhing Light;
" for a Body of Light about 15 or 20 Degrees long, parallel to the
" Horizon, roſe till it came about 6 Degrees above the black
" Baſis, and then ſent up two ſtrong Streams of Light about
" 40 gr. high, which at Top daſh'd againſt one another, and diſap-
" pear'd.

At *London*, the firſt Night, *March* 31. It did not begin to radiate, till towards Mid-night, and was ſeen but by few, the Beams not riſing very high, and ſcarce appearing over the Houſes; but by the Relation of thoſe that ſaw it, it was much more conſiderable than the next Night following *Eaſter-day*; for it then ſent out but few, and very ſhort Beams, moſtly terminating in a ſharp Point, and preſently diſappearing: Only it beginning to ſtream as ſoon as it became dusky, it was very obſervable, that thoſe Rays which aroſe out of the Weſt-end of the luminous Arch, next the Sun, were enlighten'd by its Beams, and ſhew'd themſelves much brighter than thoſe which aroſe under the Pole, or to the Eaſtward thereof. And after nine, till Midnight, no more Beams aroſe; and the luminous Arch with its black Baſis, ſettled down very low in the Northern Horizon.

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The ſame two Nights, by the Obſervation of Mr. *William Lingen*, the like Appearance was ſeen at *Dublin*, about the Hours of nine or ten; at which Time, in the former Night, it was near as light as in a Moon-light Night. And from *France*, we have an Account, that both thoſe Nights, the ſame was ſeen at *Paris*, with much the ſame Circumſtances as at *Dublin*. So that, it ſeems, this Meteor, though no Ways comparable to that of the *6th* of *March*, was ſeen not leſs than 150 Leagues, and probably much farther.

On *April* 2, when it began to be dark, a luminous Arch appear'd in the North, with a very narrow black Bottom under it, very low, and depreſs'd to the Horizon; nor was it ſeen at, or about *London*, to project any pointed Rays as the former.

But what was moſt remarkable that Evening, was, what was ſeen at *London*, by *Martin Foulks*, Eſq; about nine that Night. He being then in the open Air, ſaw in an Inſtant, a bright Ray of very white Light, appear in the Eaſt, out of the pure Sky, then very ſerene and ſtill; it very much reſembled the Tail of a Comet, and was about 20 gr. inclin'd from the Perpendicular to the Right, beginning about γ of *Bayer* in the *Corona Borea*, and terminating about the *Informis*, by ſome call'd *Cor Caroli*. This having appear'd but a very little Time, diſappear'd at once, as in a Moment: When, on a ſudden, ſuch another Beam was inſtantly produc'd, not exactly in the ſame Place, but in the ſame Situation. Its lower being about 20 gr. high, was terminated exactly between $\varkappa$ and γ, in the Right Hand and Arm of *Hercules*, and the Middle of it paſs'd over σ and ϱ in the Girdle of *Bootes*, and thence proceeded Weſtwards, leaving *Cor Caroli* four or five Degrees to the Northwards. After it had continu'd in this Poſition near ten Minutes immoveable among the Stars, it began to move ſlowly towards the North: And the lower End paſſing over the Northern Edge of the *Crown*, and the Ray it ſelf over *Cor Caroli*, it grew fainter, and vaniſh'd, having continued in all about 20 Minutes. This latter, with ſome Interruptions, was extended between *Caſtor* and *Pollux*, very far into the Weſt: And about that Time, the ſame, or ſuch another Beam, was ſeen at St. *Aſaph*, by Doctor *Stanley*.

XXVII. 1.] On *February* 5, 1716-17, at eight at Night, at *Sutton at Hone* in *Kent*, an *Aurora Borealis* appear'd. It occupied at leaſt $\frac{1}{5}$ or near $\frac{1}{6}$ of the Horizon; it was low, and ſhot out bright Rays, and, I believe, would have appear'd very light, had it not been that the Moon ſhone at the ſame Time, being about five Days old, and that the *Aurora* diſappear'd before the Moon ſet.

Two Northern Aurora's *ſeen in* Kent, *by the Reverend Mr.* E. Barrel. n. 351. p. 584.

Again, on the *30th* of *March* following, there was another *Aurora Borealis*. I ſaw it not till paſt nine: 'Twas dim then, and its higheſt Part cover'd the loweſt Star in *Caſſiopea's Chair*. It did not ſeem

ſeem due North, but one Point to the Weſt. About ten it ſhot out very bright Rays, high, and tending ſomewhat towards one another. Near eleven a Clock, there was (beſides the Northern Brightneſs) a long Streak, not very broad, extended Eaſt and Weſt; which beginning in the *Serpent's Head*, near *Hercules's Club*, and covering *Arcturus*, proceeded near *Berenice's Hair*, and ſo went over *Cor Leonis*, and thence to the *Canicula*, and ended a little beyond that Star. It ſhone very bright at firſt, but faded away in about eight or nine Minutes. If it had Motion (which I am not ſure of) it was ſouthward. I waited for the next Fit of Brightneſs of the *Aurora*; and in about ſeven Minutes, the eaſtern Part of the Streak, *viz.* from the *Serpent's Head* to near *Berenice's Hair*, became viſible again, though dim, and was quite effaced in four or five Minutes more: And I did not yet perceive any Change of its Place.

—one *of them ſeen at* London, *by* M. Foulkes, *Eſq*; n. 352. p. 586.

2.] Being in the Street, between eight and nine a Clock, on *March* 8, 1717, I perceiv'd a Light over the Houſes to the Northwards, little inferior to that the Full Moon gives when ſhe firſt riſes. Upon this, I made all the Haſte I could into the Fields, where I was for ſome Time entertain'd with the Sight of an *Aurora Borealis*, attended with moſt of the *Phænomena* of that very remarkable one of the *6th* of *March* 1715-16.

The whole Northern Part of the Horizon was in the ſame Manner cover'd with ſomewhat reſembling a very black Cloud, from behind which, there iſſued a conſiderable Light, whoſe lower Part was pretty well defin'd by the common Edge of the Cloud, but the upper died away more gradually. This upper Limb of the Light reſembling the Arch of a Circle, whoſe higheſt Point between nine and ten of the Clock (when the Meteor was moſt conſiderable) was elevated about 12 Degrees, and bore, as I imagin'd, about 20 Degrees weſtward of the due North. It touch'd the Horizon in the Weſt, at the Diſtance of about 65 or 70 Degrees from the North, whence the whole intercepted Arch of the Horizon would have been of near 100 Degrees, had not ſome few Degrees in the Eaſt been hid by Clouds, which lay between us and the Meteor.

The ſeeming black Cloud, when I firſt ſaw it, ran nearly parallel to the Horizon, and at the Diſtance of 6 or 7 Degrees, but in about Half an Hour, it changed its Figure very much, ſinking down in the North to about half its Height, and riſing in the Weſt near as much. What I principally took Notice of this for, was, that the Light iſſuing from behind it, did not change with it, but remain'd of the ſame Figure, however the Cloud approached, or receded from differing Parts of its Limb.

There aroſe at firſt, ſome Streams in the N. N. W. but of no conſiderable Length, few of them paſſing 5 Degrees above the Arch; but

beginning from behind the ſeeming Cloud, ſo as to be about 12 Degrees high in all. They were pointed at the Ends, and nearly Vertical to the Horizon. Between Times there was nothing but the Arch to be ſeen, and that only reſembling a common *Aurora*; and again in an Inſtant, by a ſort of a tremulous Motion, ſeveral Parts of it would appear converted into a vaſt Number of parallel Streams, for the moſt Part very little higher than the Arch itſelf. About 20 Minutes before Ten, a ſmall Part of the Arch, almoſt due North, grew remarkably lighter than the reſt, and continued to increaſe for about half a Minute; when there ſuddenly broke out ſome very tall Streams of at leaſt 60 Degrees high, as I found by one in particular which aroſe full North, and paſſing over the Pole Star itſelf, reach'd ſome Degrees beyond it. This was the moſt remarkable Time of the Appearance; ſome ſuch Lances, though not ſo high, immediately ſhooting out of the Place that firſt of all radiated, as did ſome more a good way to the Eaſt. They were all nearly Perpendicular to the Horizon, and moſt of them did ariſe quite from the black Subſtance at Bottom, tho' I ſaw ſome few that did not reach ſo low, appearing as if their lower Parts had been broken off. Some of them were full as bright as any I ſaw the laſt Year, the Axes (if I may ſo call them) of ſome of the talleſt Streams coming up very near to the Colour of that pale Fire we ſee in ſome ſorts of Lightning.

About this Time the Ground Weſtward was all cover'd with an odd ſort of Miſt, the ſame from which I remember laſt Year, a great many People ſaid there came an ill Smell, which I did not at all perceive.

About 10 the *Phænomenon* very much decreas'd, and ſo continu'd till after 11, only ſending up now and then two or three Streams, at half an Hour after 11 it was again pretty much encreas'd, and I ſaw it again ſend out ſome Streams almoſt as conſiderable as I had before ſeen this Evening; the Arch yet continu'd, but not ſo entire, and from what I could judge, its middle was ſome Degrees nearer the North, than when I firſt took Notice of it. Till a quarter of an Hour before 12 the Light continually abated, and then I left it; but I was inform'd, that it continued till towards Day-break, but never ſtream'd remarkably after I went away.

Though I could not this Time ſee any Stars through the black Matter at Bottom, I am ſenſible it was not a Cloud, though it bore the Reſemblance of one: For when a real Cloud (as ſeveral ſmall ones did) came over any Part of it, their Difference was very conſpicuous.

I have ſince receiv'd two Letters, one from *Wiſbich* in the Iſle of *Ely*, the other from within 14 Miles of the *Bath*, both which take Notice of it, though with no further Particulars, than that they had

ſeen

ſeen the ſame Light, tho' not conſiderable, as in the Beginning of *March* the laſt Year.

An Account of an extraordinary Meteor, *&c. by Dr.* E. Halley. n. 360. p. 978.

XXVIII. On the 19*th* of *March* 171$\frac{8}{9}$, a wonderful Luminous Meteor was ſeen in the Heavens all over *England*. Some of its *Phænomena* are very hard to account for, according to the Notions hitherto receiv'd by our Naturaliſts; ſuch is the very great Height thereof above the Earth; the vaſt Quantity of the Matter; the extravagant Velocity wherewith it mov'd; and the prodigious Exploſions heard at ſo great a Diſtance, whoſe Sound, attended with a very ſenſible Tremor of the ſubject Air, was certainly propagated through a *Medium* incredibly rare, and next to a *Vacuum*.

(†) *Vid.* Supra. p. 135.

I have formerly (†) collected what I could find of ſuch Meteors, but none ſeem to come up in any Circumſtance to this late Appearance; of which I ſhall give an Account from the many Relations thereof communicated to the *Royal Society*; tho' it was not my good Fortune to ſee it myſelf.

Sir *Hans Sloan* being Abroad at that Time, happen'd to have his Eyes turn'd towards it, in its very firſt Eruption; and gave me an Account of it in the following Terms: "That paſſing along Eaſt-"ward by the N. E. Corner of *Southampton-ſtreet* in *Bloomſbury-Square*, "*London*, at about a quarter after Eight at Night, I was ſurpriz'd to "ſee a ſudden great Light, much beyond that of the Moon, which "ſhone then very bright. I turn'd to the Weſtward where the "Light was; which I apprehended at firſt to be artificial Fire-"works or Rockets. The firſt Place I obſerv'd it in, was about "the *Pleiades* Northerly, whence it mov'd after the Manner of, but "more ſlowly than a falling Star, in a ſeeming direct Line, de-"ſcending a little beyond, and withal below, the Stars in *Orion's* "*Belt*, then in the S. W. The long Stream appear'd to me to be "branch'd about the Middle, and the *Meteor* in its Way turn'd "Pear-faſhion'd, or tapering upwards. At the lower End it came "at laſt to be bigger and Spherical, tho' it was not ſo big as the "Full Moon. The Colour of it was whitiſh, with an Eye of "Blue, of a moſt vivid dazling Luſtre, which ſeem'd in Bright-"neſs very nearly to reſemble, if not ſurpaſs that of the Body of "the Sun in a clear Day, beheld by the naked Eye. This Bright-"neſs oblig'd me to turn my Eyes (which had their Pupils adapt-"ed to the Light of the Moon) from it ſeveral Times, as well "when it was a Stream, as when it was Pear-faſhion'd and a "Globe; tho' I had a great Curioſity to obſerve it with Attention. "It ſeem'd to move in about half a Minute or leſs, about the "Length of 20°, and to go out, as I gueſs'd, about as much a-"bove the Horizon. There was left behind it, where it had

"paſs'd

" paſs'd, a Track of a cloudy or faint reddiſh yellow Colour, ſuch " as red-hot Iron or glowing Coals have, which remain'd more " than a Minute, ſeem'd to ſparkle, and kept its Place without " falling. This Track was interrupted, or had a Chaſm towards " its upper End, and about two thirds of its Length. I did not " hear any Noiſe it made, but the Place where the Globe of Light " had been, remain'd after it was extinct, of the ſame reddiſh yel- " low Colour with the Stream for ſome Time, and at firſt ſome " Sparks ſeem'd to iſſue from it, ſuch as come from red-hot Iron " beaten on an Anvil.

All the Relations agree in this, that the Splendour was little inferior to that of the Sun; that within Doors the *Candles* gave no Manner of Light; and in the Streets, not only all the *Stars* diſappear'd, but the *Moon* then nine Days old, and high towards the Meridian, the Sky being very clear, was ſo far effaced as to be ſcarce ſeen, at leaſt not to caſt a Shade, even where the Beams of the Meteor were intercepted by the Houſes: So that for ſome few Seconds of Times, in all reſpects it reſembled perfect Day.

The Time when this happen'd was generally reckon'd at a quarter paſt Eight; but by the accurate Account of the Reverend Mr. *Pound* (who only ſaw the Light) agreeing with what has been ſent us from the *Pariſian* Obſervatory, it appears to have been at 8^h 8′ apparent Time at *London*. And the Sun being then in $9\frac{1}{2}$ *gr.* of *Aries*, the right Aſcenſion of the Mid-Heaven was 130 *gr.* 45′, whereby the Poſition of the Sphere of fix'd Stars is given. Hence the *Lucida Pleiadum* will be found at that Time to have been $25\frac{1}{4}$ *gr.* high, in an *Azmuth* 6 *gr.* to the Northward of the Weſt, and conſequently the Arch the Meteor mov'd in, was inclin'd to the Horizon with an Angle of about 27 *gr.* having its Node or Interſection therewith, nearly *South South Weſt*; as will more plainly appear from what follows:

At *Oxford* five Minutes earlier, Mr. *John Whiteſide*, Keeper of the *Aſhmole Muſeum*, immediately after the Extinction of the Meteor, made Haſte out to ſee what it might be, and well conſider'd the Situation of the Track it had left in the Sky: He found it to have paſs'd about $1\frac{1}{2}$ Degree above the preceding Shoulder of *Orion*, and about $3\frac{1}{2}$ *gr.* above the middle of his *Belt*, where there appear'd a luminous *Nubecula* of a reddiſh Light, being a Dilatation of the Track, ſeeming to have been occaſion'd by ſome Exploſion there; and by what he could learn from thoſe that ſaw it, it was thereabout that it broke out, and firſt began to efface the Stars. Hence it proceeded as to Senſe in an Arch of a great Circle, and paſſing in the middle between the Tail of *Lepus* (*θ Bayero*) and *β* in the Fore-foot of *Canis major*, it terminated about *ξ* in the Breaſt of the ſame, nearly in 95 *gr.* of Right-Aſcenſion, with 23 *gr.* South Declination:

clination: And at the Place of its Extinction there remain'd a large whitiſh *Nebula*, much broader and of a ſtronger Light than the reſt of the Track, which he took for a certain Sign of a very great Exploſion made there. By Computation it will be found that the Angle this Track made with the Horizon of *Oxford* was neareſt 40 *gr.* and its Interſection due S. S. W; and that the Place of its Extinction was about 9 *gr.* above the Horizon, in the Azimuth of 32 *gr.* to the Weſt.

At *Worceſter*, Mr. *Nicolas Fatio* ſaw this Meteor deſcend obliquely towards the South, making an Angle with the Horizon of about 65°, and interſecting it about S. S. W. $\frac{1}{2}$ *S*, as may be collected from a Scheme thereof ſent up by him to the *Royal Society*. By this the Track left all *Orion* and *Canis major* to the Weſtward, and divided the Diſtance between *Sirius* and *Procyon*, ſo as to be almoſt twice as far from *Procyon* as *Sirius*. The Time here was one Minute before Eight, this City being about 9′ of Time to the Weſt of *London*, and conſequently the Right-Aſcenſion of the Mid-Heaven 128$\frac{1}{2}$ *gr.*

Now the Situation of the three Cities, *London*, *Oxford*, and *Worceſter* being nearly on the ſame W. N. W. Point, whereon the Track of the Meteor had its greateſt Altitude above the Horizon, equal to the Angle of its viſible Way; if we ſuppoſe it at *London* to have been 27 *gr.* high, and at the ſame Time at *Worceſter* to be 65 *gr.* high, in the Plane of the Vertical Circle paſſing through *London* and *Worceſter*; ſuppoſing likewiſe the Diſtance between them, to be 90 Geographical Miles, or one Degree and half of an Arch of a great Circle of the Earth, we may by a Trigonometrical *Calculus* find the perpendicular Height to have been 64 ſuch Miles; and the Point over which it was then perpendicular to have been 30 ſuch Miles W. N. W. from *Worceſter*. And the Geographical Mile to the *Engliſh* Statute Mile being as 23 to 20, this Height will be no leſs than 73 $\frac{1}{2}$ *Engliſh* Miles. The Place alſo directly under it, will be found to be about *Preſtain* on the Confines of *Hereford* and *Radnor*-Shires. The *Oxford* Obſervation too concurs nearly in the ſame Concluſion.

This Altitude being added to the Semidiameter of the Earth as *Radius*, becomes the *Secant* of eleven Degrees, ſo that the Meteor might be ſeen above the Horizon in all Places not more than 220 Leagues diſtant from it. Whence it will not be ſtrange that it ſhould be ſeen over all Parts of the Iſlands of *Great Britain* and *Ireland*, over all *Holland*, and the hither Parts of *Germany*, *France* and *Spain*, at one and the ſame Inſtant of Time.

Having thus fix'd one Point in the Line of its Motion, let us ſee what Courſe the Meteor took from thence; and firſt at the Town of *Kirkby-Stephens*, on the Borders of *Yorkſhire* and *Weſtmorland*,

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in a Meridian very little to the Weſtward of *Worceſter*, but about $2\frac{1}{2}$ *gr.* more to the North, it was obſerv'd to break out as from a duſky Cloud, directly under the Moon, and from thence to deſcend, nearly in a Perpendicular, almoſt to the Horizon. Now the Moon being at that Time in the third Degree of *Leo*, was about half an Hour paſt the Meridian, and conſequently much about a Point to the Weſt, or S. *by* W. and the Situation of *Preſtain* from *Kirkby-Stephens*, being ſufficiently near upon the ſame Point, it follows, that the Direction of the Track of the Meteor was according to the great Circle paſſing over thoſe two Places.

And this is further confirm'd by the Obſervation of *Sam. Cruwys*, Eſq; who at *Tiverton*, about twelve Geographical Miles, nearly due North from *Exeter*, obſerv'd the firſt Exploſion of this Meteor exactly in his Zenith, as he was aſſur'd by applying his Eye to the ſide of his Door, which he took to be perpendicular, and looking upwards: And from thence he ſaw it deſcend to the ſouthward directly in the ſame Azimuth, without declining either to the Right or Left: Hence it is plain, that the Track likewiſe paſs'd over this Place, which by our Maps is found to lie in a Line with *Preſtain* and *Kirkby-Stephens*.

On this Suppoſition, that the firſt Exploſion, attended with the reddiſh *Nubecula*, was directly over *Tiverton*, let us compare the *Oxford* Obſervation with it, in order to determine more nicely the perpendicular Altitude there. At *Oxford* this *Nubecula* was found to be $3\frac{1}{2}$ *gr.* above the middle Star of *Orion's Girdle*, at 8^h $3'$, and was therefore $26\frac{1}{2}$ *gr.* above the Horizon; and the Diſtance between *Oxford* and *Tiverton*, being 1° $55'$, or 115 Geographical Miles, it will be as the Sine of 61° $35'$, to the Sine of 63° $30'$. So the Semidiameter of the Earth being $3437\frac{3}{4}$ ſuch Miles, to 3498 Miles, the Diſtance of the Meteor from the Center of the Earth; from which deducting the Semidiameter, there remain $60\frac{1}{4}$ Geographical Miles for the Height of the Meteor above *Tiverton:* This is confirmed by the Obſervation of the Reverend Mr. *Derham*, who at *Windſor* ſaw the aforeſaid *Nubecula* about two Degrees above the moſt ſoutherly of the Seven Stars in the Shield of *Orion*; that is (the Time being 8^h $6'$) in the Altitude of $23\frac{1}{2}$ *gr.* Whence the Diſtance between *Tiverton* and *Windſor*, being 150 meaſur'd Miles, or 130 Geographical, by a like Proportion, we ſhall find the ſame Height of the Meteor 60 ſuch Miles, wanting only one Quarter. So that in a Round Number we may conclude it to have been juſt 60 Geographical, or 69 Statute Miles, above the Earth's Surface. Nor is it poſſible to come at a preciſe Determination of this Matter, by reaſon of the Inaccuracy of our *Data*, which were only the Notes of Perſons under the Surprize of the Suddenneſs of the Light, and no Ways pretending to Exactneſs: However, ſuch as they

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they are, they abundantly evince the Height thereof to have exceeded 60 *Engliſh* Miles, not to ſay 38 or 40, as ſome would have it.

I was unwilling to leave off, 'till I had pitch'd upon ſome Hypotheſis that might ſubject the Motion of this Meteor to a *Calculus*, that the Curious might be able to compute the viſible Way thereof, either in reſpect of the Horizon, or among the Fix'd Stars. This I found might be perform'd with tolerable Exactneſs, ſuppoſing that it mov'd in the Arch of a Circle concentric with the Earth, but 60 Geographical Miles without it; and that the Point of the firſt Exploſion was over the Latitude of 50° 40′, and 3° 40′ to the Weſt of *London*; and that of the laſt Extinction over Lat. 47° 40′, with 4° 50′ Weſt Longitude: The Time being fix'd to 8 Minutes paſt Eight at *London*. Hence it is eaſy, by a Trigonometrical Proceſs, to obtain the viſible Altitude and Azimuth of the Meteor at either of its Exploſions, as ſeen from any Place whoſe Longitude and Latitude is known; and from the Time given, the Points in the Sphere of Stars anſwering to thoſe Azimuths and Altitudes are readily deduced. Let thoſe that contend for a much leſs Height of this Meteor, try if they can, on ſuch their Suppoſition, reconcile the ſeveral *Phænomena* before recited with one another, and with the Obſervation of the Reverend Mr. *William Ella*, between *Gainſborough* and *Redford*. Here at 8^h 5′, the Meteor was ſeen to paſs preciſely in the Middle between *Sirius* and the Fore-foot of *Canis major*, moving obliquely to the ſouthward, in a Line whoſe Direction ſeem'd to be from the Middle between the two Shoulders of *Orion*. The Latitude of the Place being nearly 53° 20′, and Longitude Weſt from *London* 0° 45′. Let them try how they can account for its being ſeen five Degrees high at *Aberdeen* in *Scotland*, and near as much at *Peterhead*, half a Degree more northerly: And then let them judge whether it did not exceed the reputed Limits of our Atmoſphere. Laſtly, if the apparent Altitude of the Meteor at *Paris* was not $5\frac{1}{2}$, but 11 *gr.* on the W. *by* N. Point, when it muſt have been in its greateſt Luſtre, there will be no Pretence to bring it lower than I have made it, eſpecially if it be allow'd to have follow'd the Track I have aſſign'd it, over *Preſtain*, *Cardiff*, *Minehead*, *Tiverton*, and *Breſt* in *Britany*.

Allowing this to have been the Path it mov'd in, the real Magnitude and Velocity of this Meteor might be aſſign'd, if the ſeveral Accounts of its apparent Diameter, and of the Time of its Paſſage from one of its Exploſions to the other, were conſiſtent. But ſome of them making its viſible Appearance nearly equal to the Sun's, which, in the Opinion of many, it far exceeded, we may ſuppoſe with the leaſt, that, at the Time when it firſt broke out over *Tiverton*, its Diameter was half a Degree. And its horizontal Diſtance being 150 Geographical Miles from *London*, and its Altitude

tude 60, the Hypothenuſal or real Diſtance from the Eye, will be more than 160 ſuch Miles; to which Radius the Subtenſe of half a Degree will be above an *Engliſh* Mile and half, being about 2800 Yards *quamproximè*. After the ſame Manner it is difficult to aſſign its Velocity, whilſt ſome make it half, others leſs than a Quarter, of a Minute, in paſſing from its firſt Exploſion to its laſt Extinction: But the Diſtance it mov'd in that Time being about 3 *gr.* or 180 Geographical Miles, we may modeſtly compute it to have run above 300 ſuch Miles in a Minute; which is a Swiftneſs wholly incredible, and ſuch, that if a heavy Body were projected horizontally with the ſame, it would not deſcend by its Gravity to the Earth, but would rather fly off, and move round its Center in a perpetual Orb, reſembling that of the *Moon*.

Of ſeveral Accidents that were reported to have attended its Paſſage, many were the Effect of Fancy; ſuch as the hearing it hiſs as it went along, as if it had been very near at Hand: Others imagin'd they felt the Warmth of its Beams; and ſome there were that thought, at leaſt wrote, that they were ſcalded by it. But what is certain, is, the wonderful Noiſe that follow'd its Exploſion. All Accounts from *Devon* and *Cornwal*, and the neighbouring Counties, are unanimous, that there was heard there, as it were, the Report of a very great Cannon, or rather of a Broadſide, at ſome Diſtance, which was ſoon follow'd by a rattling Noiſe, as if many ſmall Arms had been promiſcuouſly diſcharg'd. What was peculiar to this Sound, was, that it was attended with an uncommon Tremor of the Air, and every where in thoſe Counties, very ſenſibly ſhook the Glaſs-windows and Doors in the Houſes, and according to ſome, even the Houſes themſelves, beyond the uſual Effect of Cannon, though near; and Mr. *Cruwys* at *Tiverton*, loſt a Looking-Glaſs, that being looſe in its Frame, fell out on the Shock, and was broken. Nor do we yet know the Extent of this prodigious Sound, which was heard, againſt the then Eaſterly Wind, in the Neighbourhood of *London*, as I am inform'd; and by the learned Dr. *Tabor*, who diſtinctly heard it beyond *Lewis* in *Suſſex*; but whether the Report heard near *Lewis* were of that Exploſion right over *Devonſhire*, or rather of that latter, and much greater at the Extinction over *Britany*, I ſhall not undertake to determine, till we have ſome further Accounts from *France*, whence, hitherto, we have only had, that at *Paris*, the Time of the Appearance was at 17 Minutes paſt Eight.

It remains to attempt ſomething towards a Solution of the uncommon *Phænomena* of this Meteor; and by comparing them with Things more familiar to us, to ſhew at leaſt how they might poſſibly be effected. And firſt, the unuſual and continued Heats of the laſt Summer in theſe Parts of the World, may be ſuppos'd to have

excited an extraordinary Quantity of Vapour of all Sorts; of which the aqueous, and moſt others, ſoon condens'd by Cold, and wanting a certain Degree of ſpecifick Gravity in the Air to buoy them up, aſcend but to a ſmall Height, and are quickly return'd in Rain, Dews, *&c.* whereas the inflammable ſulphureous Vapours, by an innate Levity, have a ſort of *Vis centrifuga*, and not only have no need of the Air to ſupport them, but being agitated by Heat, will aſcend in *Vacuo Boileano*, and ſublime to the Top of the Receiver, when moſt other Fumes fall inſtantly down, and lie like Water at the Bottom; the Experiment whereof was firſt ſhewn me by the Reverend Mr. *Whiteſide*. By this we may comprehend how the Matter of the Meteor might have been raiſed from a large Tract of the Earth's Surface, and aſcend far above the reputed Limits of the Atmoſphere; where, being diſingag'd from all other Particles, by that Principle of Nature that congregates *Homogenea* viſible in ſo many Inſtances, its Atoms might in Length of Time coaleſce and run together, as we ſee Salts ſhoot in Water; and gradually contracting themſelves into a narrower Compaſs, might lie like a Train of *Gunpowder* in the *Æther*, till catching Fire by ſome internal Ferment, as we find the Damps in Mines frequently do, the Flame would be communicated to its continued Parts, and ſo run on like a Train fir'd.

This may explain how it came to move with ſo unconceivable a Velocity; for if a continu'd Train of Powder were no bigger than a Barrel, it is not eaſy to ſay how very faſt the Fire would fly along it; much leſs can we imagine the Rapidity of the Accenſion of theſe more inflammable Vapours, lying in a Train of ſo vaſt a Thickneſs. If this were the Caſe, it was not a Globe of Fire that ran along, but a ſucceſſive kindling of new Matter: And as ſome Parts of the Earth might emit theſe Vapours in greater Plenty than others, this Train might in ſome Parts thereof be much denſer and bigger than in others, which might occaſion ſeveral ſmaller Exploſions, as the Fire ran along it, beſides the great ones, which were like the blowing up of Magazines. Thus we may account for the rattling Noiſe like ſmall Arms, heard after the great Bounce on the Exploſion over *Tiverton:* The Continuance of which for ſome Time, argues, that the Sound thereof came from Diſtances that increaſed.

What may be ſaid to the Propagation of the Sound through a *Medium*, according to the receiv'd Theory of the Air above 300000 Times rarer than what we breathe, and next to a *Vacuum*, I confeſs I know not. Hitherto we have concluded the Air to be the Vehicle of Sound: And in our artificial *Vacuum*, we find it greatly diminiſh'd: But we have this only Inſtance of the Effect of an Exploſion

ploſion of a Mile or two Diameter, the Immenſity of which may perhaps compenſate the extreme Fineneſs of the *Medium*.

An Account of an Extraordinary Aurora Borealis *at* London, *Nov.* 10. 1719. *by Dr.* E. Halley. n. 363. p. 1099.

XXIX. 1.] On *November* 10, 1719, in the Morning, about five of the Clock (as I was obſerving *Jupiter*) I found certain white Streaks in the Sky, ſeeming nearly Perpendicular; which, whilſt I conſider'd them, ſeem'd inſtantly to vaniſh, and ſoon after others came as inſtantaneouſly in their Room: Looking up towards the *Zenith*, I perceiv'd an entire *Canopy* of ſuch kind of white *Striæ*, ſeeming to deſcend from a white Circle of faint Clouds, about 7 or 8 Degrees in Diameter, which Circle ſometimes would vaniſh on a ſudden, and as ſuddenly be renew'd. I obſerv'd that the Centre of this Place of Concourſe was not exactly in the *Zenith*, but rather 14 Degrees to the Southwards thereof; which I eſtimated by a Star, which on each Return thereof ſhew'd its ſelf about the Centre of the Circle. This Star is the *33d* Star of the *Great Bear* in *Tycho*'s Catalogue, whoſe Diſtance from the Pole at this Time is $52\frac{1}{2}$ Degr. and which about half an Hour paſt Five that Morning paſs'd the Meridian; ſo that thoſe Rays center'd very nearly on the Meridian it ſelf. It was a very entertaining Sight, till the Day-break began to obſcure theſe Lights, which were but faint, though ſufficiently diſtinguiſhable. They came none of them lower than to about 30 or 40 Degr. of Altitude, and ſeem'd not to have aſcended from the Horizon. The Sky was perfectly Serene and Calm, which ſeems to be one of the concomitant Circumſtances attending the *Aurora Borealis*, of which this was certainly a Species. For the Night following, a Neighbour gave me notice of a ſtrange ſtreaming of Lights ſeen in the Air, which thereupon I attended from the Hours of $9\frac{1}{2}$ to 11, when a Fog came ſo thick as to put an End to my Proſpect. But during that whole Time there aſcended out of the E. N. E. and N. E. a continu'd Succeſſion of whitiſh *Striæ*, ariſing from below; and after changing, as 'twere, into a ſort of luminous Smoke, paſs'd over Head with an incredible Swiftneſs, not inferior to that of Lightning; and as it paſs'd, in ſome Part of its Paſſage, ſeem'd, as 'twere, gilded, or rather, as if the Smoak had been ſtrongly illuminated by a Blaze of Fire below. Some of the *Striæ* would begin high in the Air, and a whole Set of them ſubordinate to one another, like Organ Pipes, would preſent themſelves with more Rapidity than if a Curtain had been drawn from before them; ſome of which would die away where they firſt appear'd, and others change into a luminous Smoak, and paſs on to the Weſtwards with an immenſe Swiftneſs. And I am of Opinion, that had it not been for the Moon, then ten Days old and very bright, this for the Time would have been reckon'd as conſiderable an Appearance as that of the *6th* of *March*, 1716.

2.] On

— *the ſame in* Devonſhire, *by Mr.* W. Maunder, *ib.* p. 1101.

2.] On the 26*th* of *October*, between Seven and Eight in the Evening, I ſaw ſome ſmall Appearance of an *Aurora Borealis*, viz. three or four large Coruſcations in form of Pyramids, of reddiſh Colour inclining to Yellow, which roſe about 50 Degrees above the Horizon, and continued but few Minutes. But the North Part of the Hemiſphere was very bright and red all the Evening both before and after, till ten, if not longer.

November 10. Theſe Lights were ſeen again about four in the Morning, of which ſome ſay, that the Element open'd ſometime at one Place, then at another; from whence came great ſhining Lights that continu'd a while, and then went away by Degrees, and the Holes cloſed up again. This continu'd till Day-break.

The Evening following, coming from *Tiverton* about half an Hour after Eight, I ſaw the North Part of the Horizon very light and reddiſh (notwithſtanding the Moon being about ten Days old, was then in or paſt the Meridian, and ſhone very bright.) In a ſhort Time the ſtreaming luminous Rays began to appear very plain; ſome in one Shape, ſome another; many of them like Cones or Pyramids, but moſt of them badly terminated; ſome of which mounted very high, almoſt to the Zenith, to which Place, or near, they all or moſt ſeem'd to point. Shortly after there appear'd a long Streak of about 30 Degrees parallel to the Horizon and about 15 or 20 diſtant from it, and about two or three broad, but badly terminated, and of a fiery red Colour: Which ſent out ſome of the ſame ſtreaming Beams towards the Zenith. About ſix or ſeven Minutes after, there appear'd (ſomewhat ſudden) a circular Figure like an *Iris*, but twice as broad, of a pale Colour. The Eaſt Part was terminated by the Horizon at full Eaſt, if not ſomething to the South, and the Weſt End about North Weſt; the upper Part of its Arch being 50 or 60 Degrees high, great Numbers of luminous Rays darted from it upward and downwards, (or elſe paſſing croſs it from the Horizon) at oblique Angles pointing to the Zenith, eſpecially from the North Eaſt Part. This continu'd, as near as I can gueſs, about eight or nine Minutes, when it divided and diſappear'd. After an Interval of three or four Minutes, another *Iris*-like Figure appear'd, (of a Colour, as it ſeem'd, paler than any of the ſtreaming Lights had been) whoſe Diameter was leſs than that of the former, and ſhew'd more than its Semicircle above the Horizon, the upper Part of its Arch approaching near the Zenith. I could not obſerve any Rays to paſs from, (or a-croſs) this as from the other. The Centre of this laſt was much more to the Weſt than that of the firſt. After the Continuance of a Minute or two, it began to break in the upper Part of its Arch and ſhining Particles being ſent out from both its broken Ends towards the Zenith, (to which they were near before) or rather a little beyond it

to

to the South or South-Weſt, they there formed a ſort of *Corona*, curving and bending ſomewhat like Flames reverberated on the Arch of an Oven: Tho' this expreſſeth it but badly, yet I know not how to deſcribe it better. It ſeem'd to me and others to be finely tinged with various Colours, Red, Yellow and Blueiſh, *&c.* and ſent out every way from it (except South and South-Weſt) long Flame-colour'd Rays. After this had continu'd about two Minutes, its ſhining Light abated, and it left behind it for ſome Minutes, ſomething like a whitiſh Cloud (like in Colour to what the Light on the 19*th* of *March* laſt left behind it, after the fiery Particles were extinguiſh'd, but thinner).

All this while the Moon ſhone very bright, from which this *Corona* was not very far diſtant, perhaps not twenty Degrees, to the North-Eaſt. After this there continu'd to be ſent up many fiery colour'd or yellowiſh ſtreaming Lights, ſometimes more, ſometimes leſs; now here, now there, all along the North Part of the Hemiſphere, but moſtly from the North North-Eaſt. All this while ſomething like ſmall whitiſh Clouds (which, to me, ſeem'd to move towards the Zenith, or to point a little more Southward, but diſappear'd as they approach'd the Moon) were carry'd very ſwiftly, and at very ſhort Intervals, moſtly coming from the Eaſt and North-Eaſt, but many alſo from North and North-Weſt. We took but little Notice of this at firſt, ſuppoſing it had been nothing but the Reflection of the other Lights, or the Shadows of the Clouds (whereof the North Parts were pretty full) as the Streams of Light paſs'd behind them: But at laſt, we obſerv'd, that when the Lights at any Time abated, theſe kinds of Clouds continu'd to fly as ſwift and frequent as ever. This I ſaw till Twelve or One next Morning: Many others ſaw it next Morning till almoſt Break of Day, when it appear'd much more red and fiery than it was in the Evening; the Moon perhaps being then ſet. Some People obſerv'd tall Cones to ariſe in the Eaſt, and to be carry'd to the Weſt pretty ſwiftly in an erect Poſition, but I ſaw them not. It has been repreſented here in all ſorts of Appearances, Armies, Battles, *&c.*

3.] On the 10*th* of *November*, the Afternoon having been very calm and ſerene, about Six in the Evening the Sky was tinged with a ſtrange kind of Light, and ſome Streams began to project from the North and N. E. One of them aroſe about N. by E. and was nearly a Subtenſe of an Arc betweeen that and S. W. by Weſt; it was a little curvated toward the Sun, and what I ſaw of it (for the North Part of the Horizon was conceal'd by Houſes) very much reſembled the Tail of a Comet: About the ſame Time there was one or two which aroſe in the Eaſt, aſcending obliquely ſo as to leave the Zenith ſeveral Degrees to the Northward.

— *the ſame at* Dublin, *by* — ibid. p. 1104.

Theſe *Striæ* continu'd to appear and diſappear alternately, 'till toward Eight in the Evening; they were *Pyramidal*, and their *Vertices* frequently projected ſeveral Degrees to the South of our Zenith.

Between Nine and Ten, I was agreeably ſurpriz'd with a kind of Coruſcation, or Flaſhing, that ſhew'd itſelf between twenty and ſixty Degrees from the Zenith, in the South or South by Weſt; and which from four or five, ſometimes from more Places at once, darted with a Velocity not much inferior to that of Lightning; and by interfering with each other produc'd a beautiful Tremor or Undulation in that ſubtile Vapour, which I cannot better illuſtrate, than by comparing it to the Beams of the Sun, reflected on a Cieling from the Surfaces of two or three Baſons of Water: Theſe *Waves* of Light were only viſible at the Inſtant of Coruſcation, and were of a pale whitiſh Colour, ſomewhat reſembling the Flaſhes produced by the violent Agitation of Quickſilver in an exhauſted Receiver; but ſo ſtrong, that a Gentleman, who was in a Room by himſelf without a Candle, aſſur'd me, he took it for common Lightning: Thus it continu'd inceſſantly for more than an Hour, during which Time ſeveral lucid *Areas*, like little Clouds, diſcover'd themſelves in the pure Sky, and after they had continu'd about five or ſix Minutes, as near as I could gueſs, would inſtantaneouſly diſappear; moſt of them pretty much reſembled a very thin white Smoak or Vapour illuminated by the Full Moon.

About three quarters paſt Ten, this Vapour was almoſt ſpent, or by a briſk Gale at South by Weſt diſpers'd and driven to the Northward; at which Time, between the Weſt and North, a vaſt Body of it, like a very bright Flame-colour'd *Crepuſculum*, ſeem'd to be fix'd: From this Baſis ſeveral Beams or *Striæ* of ſhining Matter were at uncertain Intervals, emitted; and though it was not ſo ſenſible to the Eaſtward of the North, yet ſeveral mighty Pillars were alſo ejected from thence; one, which, if I miſtake not, aroſe directly under the Pole, was above all others that had preceded it, both as to its Magnitude and Denſity ſo ſurprizing, that I am perſuaded the ſmalleſt Print might have been read by the Light thereof, had not that of the Moon, which ſhone very bright, pretty much effac'd it: 'Twas tinged with a kind of Yellow and Violet Colour. In about two or three Minutes it died away, and was ſucceeded by others of an inferior Order: It was now about a quarter paſt eleven of the Clock, and nothing but repeated *Phaſes* of the ſame Spectacle offering themſelves to view; the Vibrating Motion had ceas'd; the Vapour ſhew'd itſelf no longer in lucid *Areas*, the Streams of Light were not ſo frequent, and thoſe more languid than before; and the bright *Aurora* having ſettled nearer the Horizon, I concluded the Scene was at an End, and accordingly

ingly gave over the Queſt of new *Phænomena*, with only obſerving, that about N. E. there appear'd ſome Clouds that reflected an unuſual kind of reddiſh Light. Others, who ſat up longer than I did, repreſent the End with very ſurprizing Circumſtances.

On *Tueſday* the 24*th* of *November*, we had the ſame *Phænomena* repeated, though not with the ſame Variety: About a Quarter paſt Ten at Night, a vaſt Body of ſhining Matter was collected between N. W. *by* W. and N. *by* E. in the Form of the Segment of a Circle, whoſe Center was about 25 or 30 Degrees below the Horizon; from its *Periphery* a few ſhort *Pyramidal* Streams, of the ſame luminous Vapour, aſcended by a ſlow and nearly uniform Motion, and were exceeding rare, ſo as not to efface the ſmalleſt of the Fix'd Stars; and in a Minute or two vaniſh'd: The Light which that Collection of Vapour emitted, was ſo great, that in the otherwiſe very dark Night, I could thereby (at three Quarters paſt Ten) read the Title of the laſt *Philoſ. Tranſact.* which then happen'd to lie on my Deſk; and at four or five Yards diſtance, ſee the ſmalleſt Books in my Study.

——*a return of the* ſame.

XXX. At *Streatham* in *Surrey*, on *December* the 11*th*, about one a Clock at Night (or rather in the Morning of *Dec.* the 12*th*) I was call'd to obſerve Coruſcations which appear'd of a much different Colour, and in a very different Manner, from any I had before ſeen.

An Aurora Borealis *in* Surrey, *by Mr.* T. Hearne, n. 363. p. 1107.

The Streams of Light that darted upwards from the Horizon, ſeem'd to be at conſiderably a greater Diſtance, but not at all in leſs Quantity than thoſe of *Nov.* 10. But their meeting in a Point near the Zenith, and there forming a kind of Canopy, was what was particularly remarkable in theſe Coruſcations.

The Streams of Light roſe from the Horizon only towards the North, and on each Hand towards North-Eaſt and North-Weſt: But near the Zenith a Canopy was form'd of Streams of Light meeting in a Point, not only from thoſe Quarters, but alſo from the South, *&c.* Only to thoſe Points they extended downwards from the Zenith but a little Way, and were neither in ſo great Quantity, nor quite ſo bright as thoſe Northwards. At firſt I thought the Point in which the Streams met, was exactly the Zenith, but upon obſerving it ſomething longer, I found it was not ſo, but a few Degrees to the South of the Zenith. The Streams of Light near the Zenith, which form'd this Canopy, were of a pretty bright Colour, and in great Quantity, and darted very ſwiftly.

On each Side of the North, towards E. and W. but not exactly in the N. it ſelf (at leaſt when I ſaw it) from about 10 or 15 *gr.* to 40 or 50 *gr.* above the Horizon, the Streams were of a glowing red Colour, whereas all that I had ever ſeen before, were very pale. The Redneſs was like that of a burnt Brick, and neareſt of any Thing I

have ſeen to the Colour, which remain'd for a few Minutes, like that Tract through which the Meteor paſs'd in the Spring.

The Streams appear'd of this fierce Colour when I firſt ſaw the Coruſcations, and continu'd ſo for ſome Time, till the Redneſs by degrees wearing off, in about $\frac{1}{4}$ of an Hour, they appear'd of the uſual Paleneſs, when I left them ſtill forming a Canopy near the *Zenith*.

The Air was very calm and ſerene, not a Breath of Wind ſtirring; as I remember it was alſo, *Nov.* 10.

The Moon was now a Day or two older than it was on *Nov.* 10. and a good deal farther to the Weſt, than when I ſaw the Coruſcations that Night being full South. She had now round her what is commonly call'd a Burr, larger than ordinary, and ſeveral very lucid Clouds at a little Diſtance.

Northern Aurora's *ſeen abroad*, &c. *by Dr.* T. Robinſon. n. 349. p. 483.

XXXI. I am of Dr. *Halley*'s Opinion, that thoſe Phoſphorous or Luminous Appearances in the Firmament, proceed from the various *Effluvia* perſpir'd out of our Globe, or paſſing through it; for I have ſeen thoſe Lights over *Veſuvius*, the *Strombulo* Iſlands, and towards *Ætna*, in dark Nights, when thoſe *Vulcano's* were not flaming nor burning, their Sides and Tops being paſſable to Travellers at that Time, and all their outward Parts quiet. We are certain that *Iceland* and *Greenland* abound with *Vulcano*'s; ſo may North-Eaſt *Lapland*, North *Ruſſia*, and *Tartary*, where vaſt Chains of Mountains are ſaid to run. The *Jeſuits*, and other Travellers, relate many prodigious Eruptions of Fires, and Earthquakes, towards the North of *China*; but nearer the Pole, the Earth muſt be clos'd and pent up many Months, by the long ſevere Freezings and continual Snow and Ice, which relaxing towards Spring, may give vent to that vaſt Maſs or Magazine of perſpirable Matter, that had been kept ſo long in hot Subterraneous Priſons. This may be one Reaſon why Animal Bodies themſelves are often ſenſible of Changes at that Seaſon in our Climate, when Perſpiration is upon ſuch an Increaſe.

Experiments on the Motion *of* Pendulums *in* Vacuo, *by Mr.* W. Derham. n. 294. p. 1785.

XXXII. Deſiring to know what Difference there might be between the *Vibration of Pendulums in Vacuo*, and in common *Air*, I recommended the Experiment to Mr. *Hawksbee*, who having provided himſelf with a proper Receiver, and all other Things neceſſary, with a Friend of mine in *London*, made the Experiment. The Movements he tried with were an eight Day Clock vibrating Seconds, and an half Seconds Movement of mine. The Iſſue of their Experiment was, my Pendulum vibrated two Tenths of an Inch on each Side farther in *Vacuo*, than it did in the free Air, and went ſeven Seconds ſlower in twenty Minutes, than the other Movement.

But

But in the open Air, my Pendulum in twenty Minutes, went only $3\frac{1}{2}$ Seconds ſlower than the other Pendulum.

This Experiment I try'd over my ſelf; the Inſtruments I made uſe of, were, firſt, an *Air-Pump* of Mr. *Hawksbee*'s.

The next was a *Small Movement*, with a Pendulum of about ten Inches, that vibrates *Half-ſeconds*, and is driven by the Power of a Spring. This Inſtrument I thought commodious, not only for being eaſily fitted with a Receiver, but alſo for vibrating Half-ſeconds very nicely, and alſo becauſe its Vibrations are equal, not ſome large, ſome ſhorter.

The laſt Inſtrument was a very well regulated *Month-Piece*, that vibrates *Seconds* all the Year, with as much Exactneſs as moſt do.

Being thus furniſh'd, the Reſult of many repeated Experiments, Day after Day, was, That (as before) in *Vacuo* the Vibrations were always larger than in the Receiver unexhauſted. At the firſt, when my little Movement was newly clean'd, the Vibrations were above $\frac{3}{10}$ of an Inch larger than in the free Air. But afterwards (I ſuppoſe, from ſome of the foul'd Oil of the Pump ſpirtled on the Wheels, in letting in the Air, whereby the Force of the Spring on the Pallets was blunted, from hence, I ſay) as the Vibrations in the unexhauſted Receiver were a little contracted, ſo in the Receiver exhauſted, they were more contracted, and only about 0, 25 of an Inch larger than in the free Air.

The *Alteration* in *Time*, which this Difference of the Vibrations produc'd, was conſtantly only about two Seconds in an Hour ſlower, in the Receiver exhauſted, than in it unexhauſted. For if in four, five, or more Hours going, the two Pendulums did not vary a Quarter of a Second in the open Air, or when the Receiver was put over the little Movement, (but unexhauſted); yet when the Receiver was exhauſted, the Half-ſeconds Movement would loſe, at the Rate of two Seconds in every Hour, in every Experiment, in many Hours going.

And becauſe I had a Mind to ſee what Alterations would ariſe from varying the Vibrations, therefore by opening and ſhutting the Pallets, I cauſed the Vibrations in ſome Experiments to be as large as the Receiver would bear; in others, to be as ſhort as poſſible; always adjuſting the Pendulum to vibrate Half-ſeconds nicely in the Air. But ſtill the Succeſs was much the ſame, or the difference ſcarce perceptible. But only I imagin'd when the Pendulum vibrated but a little Way from the Perpendicular, that the Vibrations in *Vacuo* were not ſo much enlarged, as when it vibrated in a larger Arch.

In all theſe Experiments (which were repeated divers Times with the ſame Succeſs) I had no other Reaſon to move me to think, but that the Vibrations were enlarg'd in *Vacuo* by the vaſt Rarefaction of

of the *Medium*, but this, That perhaps the different State of the Air might alter the Force of the Spring, which drove the Movement. For the Trial of this, I put a well-adjuſted *Pocket-Watch* (with *Hook*'s Regulator, *i. e.* the common ſmall ſpiral Spring to the Balance) into the *Vacuum*; and after ſeveral Trials, at the ſame Pitch of the Spring, I found not the leaſt Alteration in the Watch's going, in many Hours; neither the Springs, nor any other Part of the Watch, ſeeming to be in the leaſt affected by the *Vacuum*: But the Balance circumvolving, or keeping the ſame Turns, as in the open Air.

I then try'd what the Succeſs would be, by putting the Half-ſeconds Pendulum again into the Receiver, and only pumping out a Part of the Air. And accordingly I left no more Air in, than what kept the included Mercurial Gage at about ſix Inches Height; the Event of which was, that the Vibrations were then not above $\frac{1}{10}$ of an Inch larger on each Side, than in the Receiver unexhauſted: And the Time loſt but about Half a Second in an Hour, or $\frac{3}{4}$ at moſt. And ſo, according as the Mercurial Gage was more or leſs high, I always found the Vibrations greater or leſs; they gradually decreaſing, according to the Quantity of Air re-admitted. From theſe Experiments we may remark,

1. What Mr. *Boyle* long ſince obſerv'd (from a cock'd Piſtol going down as fiercely in his *Vacuum*, as in the Air) may be hereby farther confirm'd, *viz.* That the Air is not the Cauſe of the Motion or Reſtitution in Solid Bodies, as Springs. For if it was, it would certainly have been diſcover'd in ſo tender an Inſtrument as a well-adjuſted Pocket-Watch, lying under the perpetual Influence of two Springs.

2. As in *Vacuo* (where the Preſſure of the Atmoſphere is taken off) heavy Bodies deſcend quicker than they do in the open Air; ſo it may be obſerv'd, that Pendulums move ſwifter in the Receiver exhauſted, than in it unexhauſted.

That heavy Bodies deſcend quicker in *Vacuo*, is evident, from the ſwift Deſcent of the leſs heavy Bodies, as *Cork*, the *Down of Sowthiſtles*, the *lighteſt Feather*, &c. which do all precipitantly deſcend, like a Stone, in a tall exhauſted Receiver.

And that the Pendulum, in our Experiment, mov'd faſter in *Vacuo*, is manifeſt, from its vibrating but two Seconds in an Hour ſlower, when the Vibrations were $\frac{1}{5}$ of an Inch on a Side, enlarg'd by the higheſt Rarefaction of the Air. Whereas I find by Experiment, that near the ſame Increaſe of the Vibrations, doth, in the open Air, make the Pendulum go ſix or more Seconds ſlower in an Hour. I ſay, *near the ſame Increaſe*, becauſe it is ſcarce poſſible to manage the Pallets ſo, as nicely to make the ſame Vibrations as were in *Vacuo*.

3. The

3. The laſt Thing I ſhall deduce ſhall be by way of Query, *viz.* Whether the Variations of Pendulums obſerv'd under the Equinoctial, and between the Tropics, do not ariſe as much or more from the Rarity of the *Medium*, and the Encreaſe of the Vibrations conſequent thereupon? It is ſcarce, I think, to be doubted, but that the Air is much thinner and finer near the Line, than it is without the Tropics. And it is evident from the Barometer, that on the Tops of high Mountains the Atmoſphere gravitates leſs than nearer the Centre. And therefore (although I like the Notion of the Decreaſe of Gravity from the Encreaſe of the Diſtance from the Earth's Centre too well to diſcard it, yet) I am apt to think that this is not the only Reaſon of the *Phænomenon*.

I wiſh that Capt. *Halley*, when he obſerv'd at St. *Helena* his Clocks to go ſlower than in *England*, had at the ſame obſerv'd whether the Vibrations were not enlarg'd. It might be worth the while for ſuch as have Opportunity, to take Notice, whether their Pendulums between the Tropics do not make larger Arches than higher Latitudes? Alſo in what Latitude they begin to alter? Whether the Vibration be greater near the Line, than in any other Parts between the Tropics? Or, whether the greateſt Encreaſe be not always in thoſe Places where the Sun paſſeth their Zenith? If the Vibrations be found larger under the Line, or in any other Part of the Torrid Zone, then it may be obſerv'd, how much larger they are, and in what Proportion they encreaſe, or decreaſe, by approaching nearer unto, or receding from the Place of their greateſt Encreaſe?

Alſo it may be worth obſerving, Whether Pendulums do not vary on the Tops of high Places, or in different States of the Atmoſphere, according as the *Mercury* is high or low in the Barometer? But then in this, and indeed in the former Caſes, it is neceſſary, or at leaſt very expedient, that the Movement be ſo exactly well made, that the Power, whether Weight or Spring, do at all Times exert the very ſame Force upon the Pads or Pallets. For moſt Clocks are apt to vibrate ſometimes larger, ſometimes leſſer Arches in the 24 Hours, according as the Weight or Spring doth more or leſs exert its *Forces* on the Work.

XXXIII. 1.] A Candent Iron being included in a Recipient proper for that Purpoſe, and the Air withdrawn (which was in about two Minutes of Time) the *Mercury* then in the Gage ſtanding at 29 Inches $\frac{1}{2}$, a Quantity of Gun-powder was immediately made to deſcend upon the red hot Iron, which contin'd upon the Surface of it ſome ſmall Time before it went off, and then was obſerv'd not to fire all at once, and the laſt of the Quantity that did ſo, ſeem'd to give the greateſt Flaſh; upon which the Mercurial Gage

An Experiment of firing Gun-powder *in* Vacuo, *by Mr.* F. Hawkſbee. n. 295. p. 1086.

Gage was taken Notice of to deſcend ſomething more than an Inch, it riſing again $\frac{1}{10}$ of the ſame: And upon ſeveral Repetitions of the like Quantity of Powder (the factitious Air being always withdrawn) the Appearances were very reſembling. Again upon purging the Recipient of the factitious Air, and the *Mercury* elevated in the Gage, as at firſt, three Quantities were cauſed to deſcend upon the Iron, whoſe Exploſion as well as the Air produc'd from them, ſeem'd in Proportion to the Quantity of Powder; the *Mercury* then in the Gage ſubſiding to 26. But upon dropping ſix Quantities (the Recipient being firſt purg'd as before) which Quantities not deſcending all at once, but ſucceſſively as faſt as might be, the Quantities that firſt reach'd the (ſtill Ignited) Iron taking Fire, by their Flame making an Exploſion of the whole, at once blowing up the Recipient, although the Weight of the Air incumbent on it was equal to 144 *l.* $\frac{1}{2}$, accounting the Receiver at 3 Inches $\frac{1}{2}$ Diameter, but was ſomething more, which does ſufficiently allow for the want of Height of *Mercury*. The Gage then ſtanding at 29 $\frac{1}{2}$, inſtead of 30, from which the Calculation is made. The Gun-powder us'd was the common glaz'd ſort; and the Weight of the ſix Quantities, which remov'd the Recipient, with ſo great a Preſſure incumbent on it, was but ſeven Grains, each Quantity weighing ſomething more than one. I did not obſerve the Recipient to be broke before it reach'd the Floor. It was thick lin'd with Sulphureous and Nitrous Steams, ſo that the Flaſhes of Fire through the Cloudineſs of the Glaſs ſeem'd very much to reſemble faint Lightnings. The Content of the Receiver was equal to about 25 Ounces $\frac{1}{2}$ of Water, allowing for the Bulk of Iron and Pedeſtal.

The Quality *of the* Air *produc'd by* Gun-powder *by the* ſame, *ibid.* p. 1807.

2.] Upon making the late Experiment before the *Society*, of firing Gun-powder *in Vacuo*, it was hinted as well worthy of Trial, Whether the factitious Air of fir'd Gun-powder was endu'd with any Quality differing from common Air? In order to the Satisfaction of the Query, I included a Candent Iron *in Vacuo*, the *Mercury* then in the Gage ſtanding at 29 Inches $\frac{1}{2}$: Upon dropping the firſt Quantity of Powder, (by a Quantity is to be underſtood ſomething more than a Grain weight) its Exploſion made a Deſcent of the *Mercury* in the Gage about an Inch, undulating very little. The ſecond Quantity being let fall, the *Mercury* ſubſided about $\frac{3}{4}$ of an Inch; and ſo for ſeveral Quantities following it deſcended by pretty equal Stages, till it had fallen about ſix or ſeven Inches; and it was obſerv'd, upon every Quantity fir'd, the Undulations of the *Mercury* increas'd. But after it had ſubſided ſix or ſeven Inches from 29 $\frac{1}{2}$, the ſeveral Deſcents of it became leſs, very little or nothing exceeding $\frac{1}{2}$ an Inch, although the Quantities firſt were equal; but

ſtill

ſtill the Undulations encreas'd, and the Exploſions manifeſtly did ſo too: 'Till at laſt the Receiver ſeem'd to be in great Danger of being blown up by a ſingle Quantity, the Undulations of the *Mercury* being then augmented to ſix or ſeven Inches. Now 26 Quantities or 32 Grains having been fir'd upon the Iron, and the *Mercury* in the Gage fallen to 12 $\frac{3}{4}$, I diligently attended to obſerve the Gage, which in ſeven Minutes had aſcended 2 Inches $\frac{3}{4}$, the next five Minutes it aroſe but 1 Inch $\frac{1}{4}$, and ſo leſs ſucceſſively every five Minutes, that in an Hour and 17 Minutes, it had attain'd but to 21 Inches, the Iron not being quite cold. At Nine the ſame Night I obſerv'd the Gage, and found the *Mercury* elevated to 22 Inches $\frac{1}{4}$ preciſely: Next Morning at Nine it had attained to 22 $\frac{1}{2}$, and ſo continu'd all that Day, the Iron then being reduc'd to the Temperature of the outward Air. So that from 12 $\frac{3}{4}$ to 22 $\frac{1}{2}$, ſeems to be the Weight or Spring of Heat equal to about $\frac{1}{3}$ of an Atmoſphere of Air, which would preſs the *Mercury* upon the upper Part of the Gage, but equal to ſuch a Degree of Heat as was then contain'd in the Receiver, when the Gage was fallen to 12 $\frac{3}{4}$: The remaining Space from 22 $\frac{1}{2}$ to 29 $\frac{1}{2}$ is ſuppos'd to be ſupply'd with factitious Air, and anſwers to about $\frac{1}{4}$ Part of the Recipients whole Content, which was equal to 25 Ounces $\frac{1}{2}$ of common Water, allowing for the Iron and Pedeſtal. This Air produc'd from Gun-powder, I find to be actuated by Heat and Cold as common Air: For, holding my warm Hands upon the Receiver, the *Mercury* in the Gage would immediately deſcend, and riſe again when reduc'd to the Temperature of the outward Air. This I repeated ſeveral Times with the like Succeſs. What more occurs in this Experiment is, Why the Exploſions of the like Quantities of Gun-powder ſhould be greater when reſiſted by Air, than in *Vacuo*, where nothing ſeems to hinder the Extenſion of their Flame.

Deſcent of Malt-Duſt *in* Vacuo, *by Mr.* F. Hawkſbee. n. 298. p. 1948.

XXXIV. I took ſome Malt Duſt, and having well dry'd the ſame, put a Quantity of it into a fine Muſlin Bag, where being looſely inclos'd, it would, upon ſhaking, diſcover itſelf plentifully in the open Air, undulating and floating a conſiderable Time before it would deſcend; but being included within a Receiver, from which the Air was well exhauſted, and then ſhaken, the Duſt deſcended as a ponderous Body, precipitating in ſtraight Lines from the Top to the Bottom of a tall Receiver.

An Experiment *to prove an* Interſpers'd Vacuum, *by Dr.* J. T. Deſaguliers. n. 354. p. 717.

XXXV. Having had the Honour to make ſome Experiments laſt Year before *His Majeſty* and their *Royal Highneſſes the Prince and Princeſs of* Wales; among others, I ſhew'd that of a Guinea and a Piece of fine Paper; then of a Guinea and a Feather dropp'd together from the Top of an exhauſted Glaſs Receiver about 20 Inches

Inches high; both which fell to the Bottom at the ſame Inſtant of Time: Now ſince the chief Reſiſtance of a *Medium* (and indeed almoſt all of it) depends upon the (†) Quantity of its Matter; therefore this Diminution of Reſiſtance, whereby the Feather fell as ſoon as the Guinea, ſhew'd a Diminution of the Quantity of Matter, and conſequently prov'd an *interſpers'd Vacuum.* Some Time after this, I was inform'd, that ſome *Pleniſts* objected againſt the Shortneſs of the Glaſs-Receiver; as if the Difference of Time in the Fall of the two Bodies, which they affirm'd to be real, could not be perceiv'd in ſuch a Glaſs; and that ſome Philoſophers from abroad affirm'd, that in a Glaſs-Receiver ſeven or eight Foot long, there would be ſuch a manifeſt Difference in the Time of the ſaid Bodies, as to ſhew this Experiment no Proof of a *Vacuum:* To obviate this, I contriv'd a Machine for the Purpoſe, which conſiſted of a ſtrong Wooden Frame 15 Foot high, that held the Air-Pump and four Cylindric Glaſs-Receivers of about two Foot long each, and ſix Inches Diameter: Of theſe, having ſet the firſt upon the Air-Pump-Plate, I laid on the Top of it a Braſs-Plate of ſeven Inches Diameter, that had an oil'd Leather fix'd to it above and below, with an Hole through the Middle, of between four and five Inches Diameter; then on that Plate I ſet the next Receiver, with a like Plate at Top; and after the ſame Manner fix'd the other two with Plates between them: The upper Receiver being a little narrower at the Neck, went into the Hole of a Board, whereby it was ſcrew'd down pretty hard on the other Glaſſes, and fix'd to the whole Machine. On the Top of this upper Receiver, I had the Braſs Plate, wet Leather, and Braſs Springs which contain'd the Bodies to be dropp'd.

(†) *See Sir* If. Newton's *Principia*, Book II. Prop. 40.

Having acquainted his Majeſty with what I had prepar'd, he order'd me to ſhew him the Experiment with this long compounded Receiver, at *Hampton-Court*; and when I made it before him and her Royal Highneſs, he was pleas'd (by pulling down a String fix'd to a Leaver at the Top of the Machine) to let looſe the Bodies himſelf.

When the Receiver was full of common Air before Pumping, the Guinea came to the Bottom, juſt as the Paper was about the Middle of the ſecond Glaſs; but when the Receiver was exhauſted, the Guinea and Paper came to the Bottom preciſely in the ſame Inſtant of Time.

Upon my giving an Account of the Succeſs of this Experiment to the *Royal Society*, they order'd me to repeat it before them on the 5*th* of *December* 1717.

I made the Experiment firſt with two of the Receivers; then with all the four; dropping a Guinea and a ſmall Piece of Paper together; and the Succeſs anſwer'd Expectation: But not being willing

willing to try with a Down Feather, becauſe I fear'd the Air might inſinuate between ſome of the Glaſſes, by reaſon the Number of Perſons preſent ſhak'd the Room, the Society order'd me to make the Experiment at Home, before one or more of their Members.

Martin Foulkes, Eſq; was preſent when I made the Experiment at my Houſe, where we made four Trials in the following Manner:

The whole Machine being fix'd, as above mention'd, we firſt let fall a Guinea and two Papers, the one plac'd over, and the other under it, (before any Air was pump'd out) and the Guinea came to the Bottom when the Papers were only in the Middle of the ſecond Glaſs from the Top. Then having laid a Feather on the Braſs-Springs cloſe by the Guinea, we let them looſe both together; and the Feather was fallen only down to the fourth Part of the Length of the firſt Glaſs, or one ſixteenth of the whole Diſtance, when the Guinea was got down to the Bottom of the Receiver. We then laid two Papers and two Feathers, one of each under, and the other over the Guinea between the Springs; and having drawn out ſo much of the Air as to bring up the *Mercury* in the Gage-Tube within a Quarter of an Inch of the greateſt Height to which it could be then rais'd by the Preſſure of the external Air, we caus'd the Bodies to fall all at once: And though the Papers came down to the Bottom at the ſame Time as the Guineas, yet the Feathers, being much lighter, wanted about three Inches. But at laſt, having laid the Papers, Feathers, and Guinea, as before, we pump'd out all the Air, and then the Feathers, as well as the Papers, came to the Bottom of the Receiver at the ſame Inſtant of Time as the Guinea.

XXXVI. 1.] I took twelve Balls (ſix of which were ſolid Leaden Globes, of about two Inches Diameter; three hollow Glaſs Balls of about five Inches Diameter; and three light Paſteboard hollow Globes of about the ſame Diameter) and having carried them to the upper Gallery in the Lanthorn, on the Dome of St. *Paul*'s Church, I caus'd them to fall down by two at a Time, in the following Manner;

Experiments *to find how much the* Reſiſtance *of the* Air *retards* Falling Bodies, *by Dr.* J. T. Deſaguliers. n. 362. p 1071.

Firſt, a Leaden Ball and a Glaſs Ball.

Secondly, a Leaden Ball and a Glaſs Ball.

Thirdly, a Leaden Ball and a Glaſs Ball.

Then I let fall, in the ſame Manner, the three other Leaden Balls, each with a Paſteboard Ball.

After that, having the Leaden and Paſteboard Balls brought up again, I repeated the Experiment twice more with a Leaden and Paſteboard Ball: Then I made the Experiment twice more with a Paſteboard Ball alone, to ſee how long it would be in falling.

Upon the whole it appear'd, that the Leaden Balls were a very little longer than $4\frac{1}{2}$ Seconds in falling; the two largeſt of the Glaſs Balls 6 Seconds, and the Paſteboard Balls $6\frac{1}{2}$ Seconds.

The Height of the Gallery, from whence the Bodies fell, was 272 Foot above the Pavement of the Church (then cover'd with Boards) upon which they fell.

The Times of the Falls were taken two Ways above, *viz.* with a Wheel-Chronometer, which meaſures a ſmall Part of Time accurately, nearer than to a Quarter of a Second, (made and contriv'd by Mr. *Graham*) and with an $\frac{1}{2}$ Second Pendulum: And the Differences of Time between the Fall of the Leaden Balls, and the other Balls, were taken below, by Sir *Iſaac Newton*, *Martin Foulkes*, Eſq; and another Perſon, who all agreed in their Obſervations of the Time, which they made each with an half Second Pendulum.

The following Table gives the Marks, Weights, and Diameters, of the ſeveral Balls, in three Columns.

Leaden Balls.	*Troy Weight.* *l.* *oz.* *d.*	*Diameters in Inches and Decimals.*
1 *c*	2 : 1 : $\frac{1}{2}$	2 , 1
2 *c*	1 : 11 : 4	1 , 99
3 *c*	1 : 11 : 12	2 , 0
4 *c*	1 : 11 : 12	2 , 0
5 *c*	1 : 11 : 12	2 , 0
6 *c*	1 : 10 : 00	1 , 98
Paſteboard Balls.		
A	0 : 3 : 6	5 , 5
B	0 : 1 : 14	5 , 1
C	0 : 1 : 17	5 , 1
Glaſs Balls.		
D	0 : 3 : 13$\frac{1}{2}$	3 , 9
E	0 : 5 : 3$\frac{1}{2}$	5 , 42
	0 : 6 : 0$\frac{1}{2}$	5 , 55

N. B. The Polar and Equatorial Diameters of the Glaſs Balls being different, I have ſet down a mean Diameter for each of 'em; the true Diameters are thus, of D 4 and 3,8. of E 5,6 and 5,25. of F 5, 7 and 5,4 Inches.

The particular Experiments are as follows.

Exp. I. Fall of 1 *c* and D. *c* fell by the Pendulum in $4\frac{1}{2}''$. The Fall of D was ſo near it, that the Difference was not taken either above or below.

Ex-

Exp. II. Fall of 2 *c* and E.

2 *c* fell by the Chronometer in 5″, by the Pendulum in $4\frac{1}{2}$″. Time of the Fall of E not taken above. The Difference taken below $1\frac{3}{4}$″.

Exp. III. Fall of 3 *c* and F.

3 *c* fell by Chronometer in $4\frac{1}{2}$″, by the Pendulum in $4\frac{1}{2}$″. F fell in ſix Seconds. The Difference taken below, was $1\frac{1}{2}$″.

Exp. IV. Fall of 4 *c* and A.

4 *c* fell by Chronometer in $4\frac{3}{4}$, by the Pendulum in $4\frac{1}{2}$. A fell in $6\frac{1}{2}$ Seconds. Difference taken below = 2″.

Exp. V. Fall of 5 *c* and B.

We made no Obſervation above nor below.

Exp. VI. Fall of 6 *c* and C.

6 *c* fell by Chronometer in $4\frac{3}{4}$″, by the Pendulum in $4\frac{3}{4}$″. C not taken above. Difference below = $2\frac{1}{4}$″.

Exp. VII. Fall 1 *c* and B.

1 *c* fell by Chronometer in $4\frac{3}{4}$″, by the Pendulum in $4\frac{3}{4}$″. B not taken above. Difference taken below $2\frac{3}{8}$″.

Exp. VIII. Fall of 5 *c* and A.

5 *c* fell by the Pendulum in $4\frac{3}{4}$″. A fell foul, and ſo was not obſerv'd at all. Difference taken below 2″.

Exp. IX. Fall of B alone.

By the Chronometer in $6\frac{1}{2}$″, by the Pendulum in $6\frac{1}{2}$″.

Exp. X. Fall of C alone.

By the Chronometer in $6\frac{1}{2}$″, by the Pendulum in $6\frac{1}{2}$″.

By *Galileo*'s Theory, the Lead, which was $4\frac{1}{2}$″ in falling, muſt fall four Foot the firſt $\frac{1}{2}$″; or ſixteen Feet the firſt Second, which amounts to 324 Foot in $4\frac{1}{2}$″. But as the Sound of the Ball (as it ſtruck the Bottom) by which we reckon'd our Time, had 272 Feet to move, we muſt abate a $\frac{1}{4}$ of a Second nearly, (ſuppoſing Sound to move one Mile in $4\frac{1}{2}$″) which will take away 35 Feet, that the Body muſt have fallen in the laſt $\frac{1}{4}$ of a Second, and reduce the Number of Feet to 289: So that the Lead will have only fallen 17 Feet ſhort of the Theory, which muſt be attributed to the Reſiſtance of the Air.

The large Glaſs Ball in the 6 Seconds of its Fall, would in a *Vacuum* go through 576 Feet: But taking away the laſt $\frac{1}{4}$ of a Second 47 Feet, for Motion of Sound, it muſt only fall 529 Feet in *Vacuo*. Now ſince it fell but 272, there have been 257 Feet taken off from the Fall by the Air's Reſiſtance.

Likewiſe the Paſteboard Ball in $6\frac{1}{2}$ Seconds muſt have fallen 676 Feet: But deducting the laſt Quarter of a Second, or 51 Feet, for the Motion of the Sound, there remains only 625 Feet for its Fall in *Vacuo*. But as it fell only 272 Feet, we muſt allow a Retardment of 353 Feet for the Reſiſtance of the Air.

At

At a Mean we may call the Weight of the Glaſs Ball five *Oz. Troy*, and its Diameter 5 Inches and $\frac{1}{2}$; and the Weight of the Paſteboard Ball two Ounces *Troy*, and a little more than five Inches Diameter.

The Lead Balls all fell within near a Foot of one another, and made an Impreſſion in the Boards of about $\frac{1}{5}$ of their Depth.

The Barometer ſtood at 30, 1 Inches, and the *Mercury* was very convex, and therefore inclin'd to riſe ſtill.

Some further Experiments *on the* ſame, *by the* ſame, *ibid.* p. 1075.

2.] Having found by our former Experiments, that thin Glaſs Balls, and even Balls of paſted Paper, were too heavy to make ſo conſiderable a Difference between the Time of their Fall and the Fall of Leaden Balls, that it might be eaſily obſerv'd; I contriv'd a Way to make dry'd Hog's Bladders perfectly round, by blowing them (when moiſt) within a ſtrong ſpherical Box of *Lignum Vitæ*, and letting them dry in the ſaid Box before I took them out: Which I did by opening the Box that ſcrew'd in the Middle, and had a Hole in the Pole of one of its Hemiſpheres to let the Bladder paſs through, in order to tie it after blowing; and ſome few ſmall Holes all over the Box, that, in blowing, no Air might be confin'd between the inſide of the Box and the Bladder, ſo as to hinder it from putting on a ſpherical Figure. Beſides, I took off the Ends of the *Ureters*, the Fat, and a great deal of the upper Coats of the Bladders, before I blow'd them in the Box, to render them ſtill lighter.

The Bladders I us'd, were ſome of the thinneſt I could find ready blown at a *Druggiſt*'s, which I moiſten'd in Water, taking Care to leave none in the inſide.

Having prepar'd five Bladders in the Manner aforeſaid, I took them up to the upper Gallery in the Lantern on the Top of the *Cupola* in St. *Paul*'s Church; and there, by a Contrivance which I ſhall deſcribe, I let them fall by one at a Time, together with a Leaden Ball of about two Inches Diameter, and weighing 2*l. Troy*: And I took Notice of the Time of the Fall of each Bladder, knowing by former Experiments that the Balls are about $4\frac{1}{4}$ Seconds, or a little longer Time, in falling the ſame Height, which is 272 Feet.

The following Table, conſiſting of five Columns, gives in the firſt, the Marks of the Bladders; in the next their Diameters; in the third their Weights, in Grains *Troy*; in the fourth the Times of their Fall in Second Minutes of Time; and in the fifth, the Difference of Time between the Falls of the Leads and of each Bladder; taken below by Sir *Iſ. Newton*, Dr. *Halley*, Dr. *Jurin*, *Martin Foulkes*, Eſq; and Mr. *Graham* the Clock-maker. The Time was taken above with Mr. *Graham*'s Chronometer; and below with the ſame Inſtrument,

ment, and three half Second Pendulums, all which agreed very well together.

The Experiments having been made twice over, the Table is twice ſet down; and thoſe Experiments in which the Bladders fell ſtreight down, and the moſt regularly, have this Mark before them (*)

Marks.	*Diameters in Inches.*	*Weight in Grains Troy.*	*Time of the whole Fall.*	*Diff. between the Lead and Bladder.*
A	5, 3	128	19 3/8″	14 2/8 Seconds.
* B	5, 193	156	17 1/4	12 3/4
C	5, 33	137 1/2	18 3/4	14 5/8
D	5, 26	97 1/2	22 2/8	17 6/8
* E	5, 02	99 1/8	21 5/8	17
* A			19″	14 1/2
B			18 5/8	14 1/4
* C			18 3/8	14
D			24	19 1/8
E			21 1/4	16 6/8

The Diameters and Weights may be rely'd upon, being taken the Day that the Experiments were made, and the Day after; but the Diameters and Weights taken ten Days before, not agreeing with theſe, I have left them out. For the Bladders by drying had loſt their Weight, and alter'd their Diameters.

As the Necks of the Bladders in drying ſhrink, ſo as to open a little, they muſt be blown before each Experiment. And for the Manner of letting them fall exactly in the ſame Inſtant of Time, it is deſcrib'd by *Figure* 25, in which

A, A, A, A, is the Hole through which the Bodies fell: 1, 2, is a Board laid over the Hole. G, D, D is another Board fix'd to the firſt Board by the two Wood-Screws D, D with a Pulley G at the other End of it, over the Hole. W, is a two Pound Ball of Lead faſten'd to a ſtrong Thread, which going over the Pulley, is ſtretch'd horizontally from G to the Nails F; to which it is faſten'd, ſo as to be about a quarter of an Inch above the Board. *Fig.* 25.

B is one of the Bladders, hanging with the Neck or heavieſt Part downwards, by Means of a Loop of fine Thread as E H, which goes over the Horizontal Thread G E F. Now when with a Pair of Sciſſars the Thread of the Lead (which in all is but one Foot long) is cut juſt at E, before the Loop of the Bladder, the Lead pulling away the String, the Loop of the Bladder ſlips off the remaining Thread F E, and begins to fall exactly in the ſame Inſtant as the Lead: But if the Thread ſhould be cut between E and F, as

F, as the Lead falls, its Thread might give the Bladder an oblique Direction.

He that obſerves the Time either with a Pendulum or Chronometer may take it very exactly, by ſeeing the Motion of the Sciſſars as they cut the Thread.

N. B. As the Diameters of the Bladders were taken by wrapping a Thread twice round them, and ſomething muſt be allow'd for the Thickneſs of the Thread; I have here under ſet down the Diameters of the Bladders, as corrected by that Allowance. *Viz.* A 5, 28 Inches; B 5, 19; C 5, 30; D 5 ¼; and E juſt 5 Inches in Diameter.

The Bladder E was rough, with ſeveral Wrinkles and Inequalities, which made it be longer in falling than it ought to have been, according to its Diameter and Weight.

A Pail of Water thrown down met with ſuch a Reſiſtance in falling 272 Foot through the Air, that it was all turn'd into Drops like Rain.

XXXVII. *Papers*, &c, *of Mr.* Hawkſbee's *Omitted.*

n. 303. p. 2129. 1. An Account of ſeveral *Experiments* on the *Mercurial Phoſphorus*, made before the *Royal Society*.

n. 304. p. 2165. 2. An Account of ſeveral *Experiments*, made before the *Royal Society*, concerning the *Attrition* of *Bodies* in various *Mediums*. — Of *Amber* on *Woollen* in *Vacuo*. — Of *Flint* on *Steel* in *Vacuo*. — Of *Glaſs*, and various other Bodies in *Vacuo*. — Of *Glaſs* on *Woollen* — of *Glaſs* on *Oyſter-Shells* — of *Oyſter-Shells* on *Woollen* — of *Woollen* on *Woollen* — of *Glaſs* on *Glaſs* — of *Glaſs* on *Glaſs* under *Water*.

n. 307. p. 2277. 3. An *Experiment* concerning the Production of *Light* on a ſlight *Attrition* of the *Hands* on a *Glaſs Globe* exhauſted of its *Air*, &c.

n. 308. p. 2327. 4. An *Experiment* concerning the *Electricity* of *Glaſs*, produc'd by a ſmart *Attrition* of it.

Ibid. p. 2332. 5. A Continuation of the *Experiments* of the *Attrition* on *Glaſs*.

n. 309. p. 2372. 6. Some further *Experiments* relating to the *Electricity* of *Glaſs*, and of the *Effects* of the *Effluvia*, &c.

n. 310. p. 2313. 7. An *Experiment* confirming a former one, concerning the Production of *Light* by the *Effluvia* of one *Glaſs* falling on *another* in Motion.

Ibid. p. 2415. 8. An *Experiment* ſhewing the Difficulty of *Separating* two *Hemiſpheres*, upon the injecting of an Atmoſphere of *Air* on their *Outward Surfaces*, without *exhauſting* the included *Air*.

n. 305. p. 2221. 9. An *Experiment* concerning the *Proportion* of the Weight of *Air*, to the Weight of an equal Bulk of *Water*, without *knowing* the abſolute *Quantity* of either.

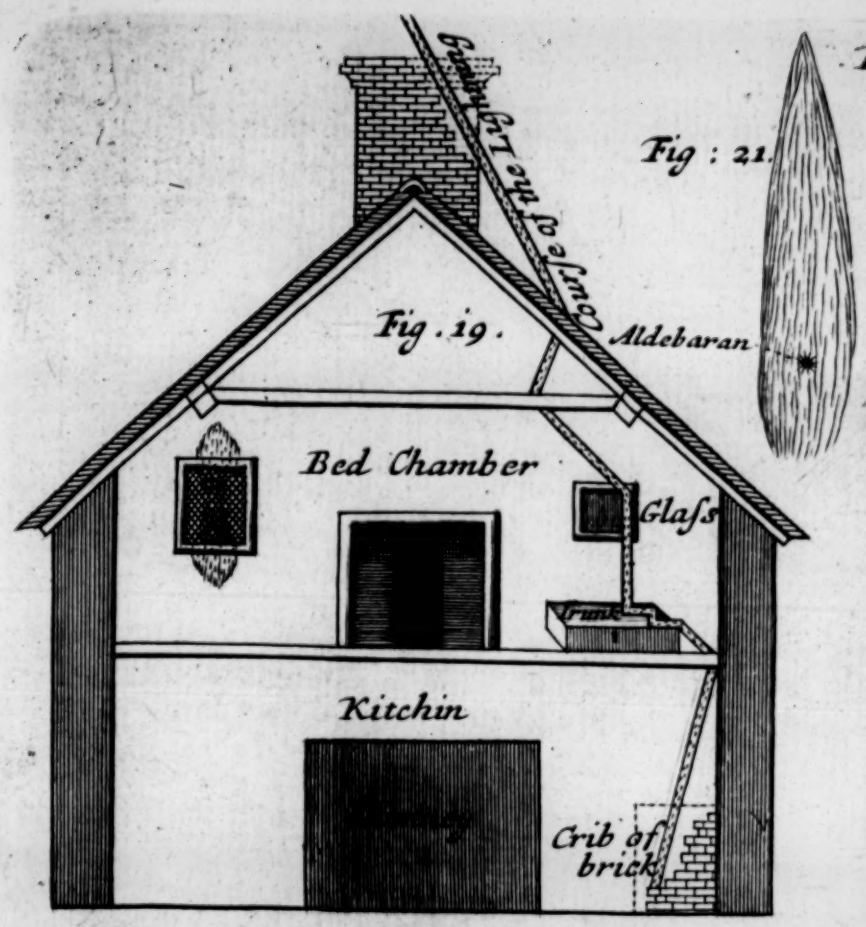


Fig. 19.

Fig: 21.

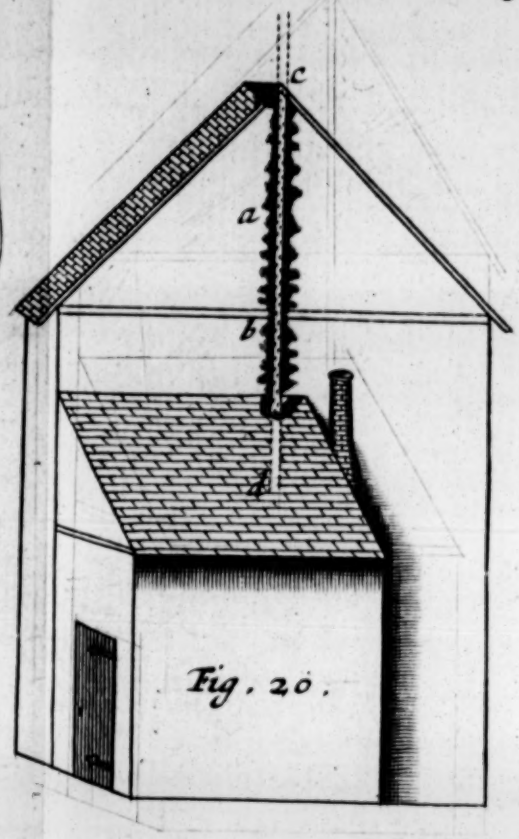


Fig. 20.

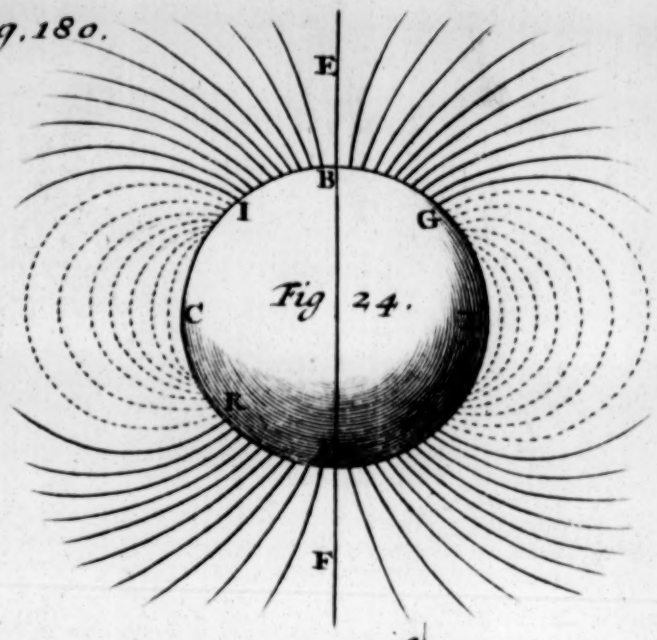


Fig 24.

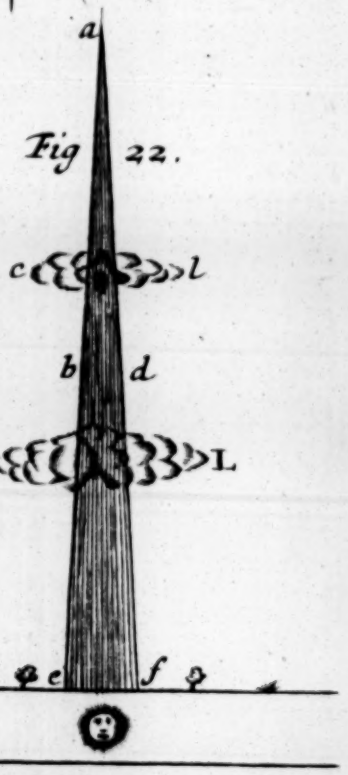
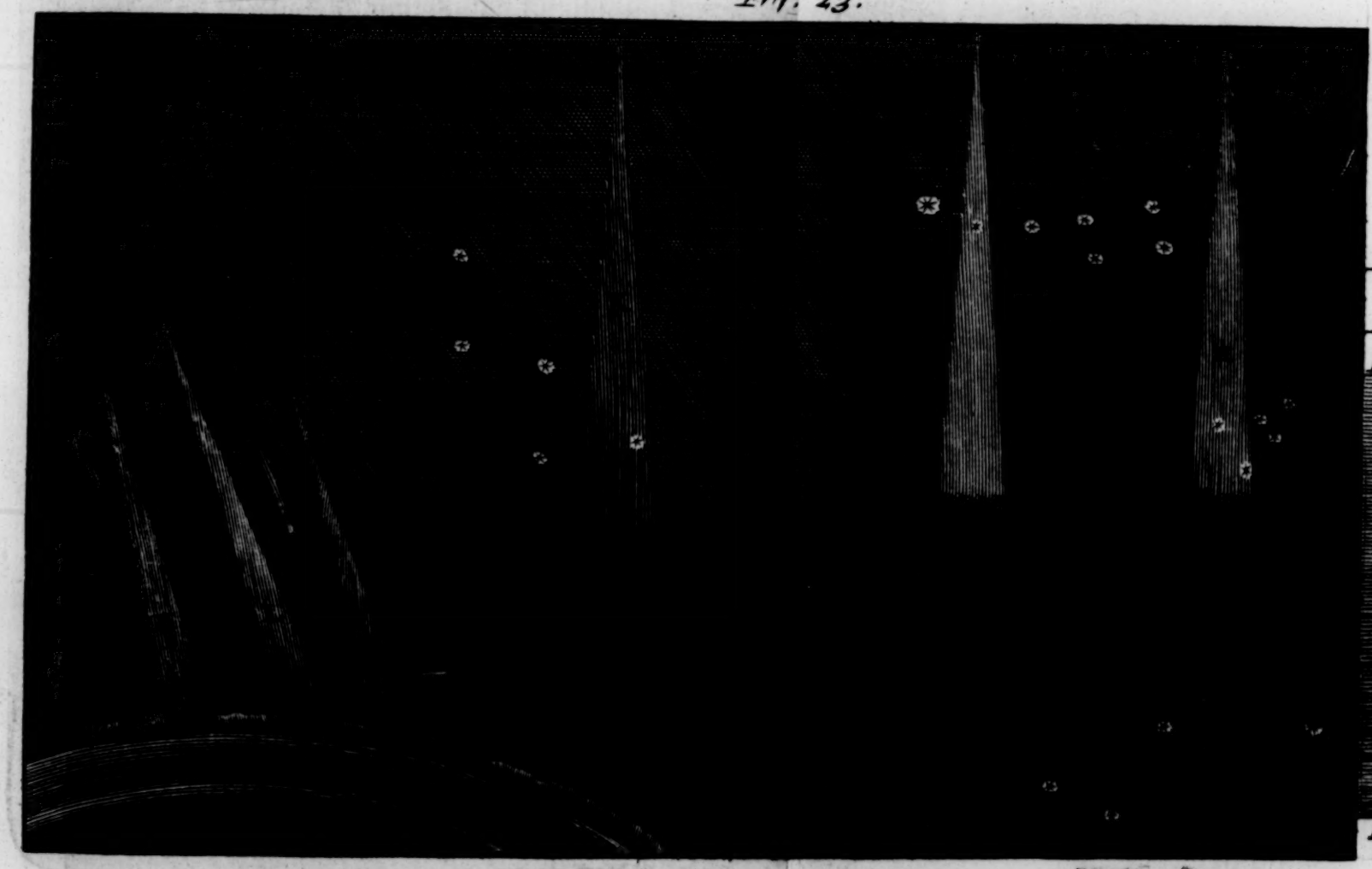


Fig 22.

Fig: 23.



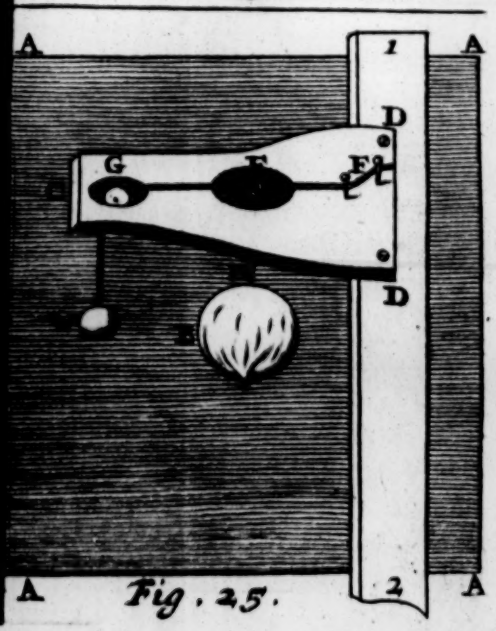


Fig. 25.

10. An *Experiment* ſhewing, that the *Aſcent* of *Liquids* in *Small Tubes* open at both Ends, is the ſame in *Vacuo* as in the open *Air*. *Ibid.* p. 2223.

11. An *Experiment* concerning the *Quantity* of *Air* produc'd from a certain *Quantity* of *Gun-powder* fir'd in common Air. n. 311. p. 2409.

12. An *Experiment* ſhewing, that the *Springs*, or conſtituent Parts of *Air* are capable of ſuffering ſuch *Diſorder* by a violent *Impulſe*, as to require Time to recover their Natural State. *Ibid.* p. 2412.

13. An *Experiment*, ſhewing the *Cauſe* of the *Deſcent* of the *Mercury* in the *Barometer* in a *Storm*. n. 292. p. 1629.

14. *Experiments* on the Production and Propagation of *Light* from the *Phoſphorus* in *Vacuo*. n. 296. p. 165.

15. *Experiments* concerning the Propagation of *Sounds* in *Condenſed* and *Rarefied* Air. n. 297. p. 1902.

16. *Experiments* concerning the *Reſilition* or Rebounding of *Bodies* in *Various Mediums*. n. 298. p. 1946.

17. Some farther *Experiments* concerning the *Electricity* and *Light* produc'd from various *Bodies* by *Attrition* — of *Glaſs* — of *Sealing-Wax* — of *Sulphur* and *Roſin*. n. 315. p. 82.

18. An Account of the Succeſs of an *Attempt* to continue *ſeveral Atmoſpheres* of *Air* condens'd in the *Space* of *One*, for a conſiderable *Time*. n. 318. p. 217.

19. An *Experiment* concerning the Production of *Light* in an exhauſted Glaſs, *lin'd* on the *Inſide* with *Sealing-Wax*, upon an *Attrition* made on its *Outſide*. n. 318. p. 219.

20. *Experiments* concerning the *Aſcent* of *Liquids* between the *nearly contiguous Surfaces* of Bodies — between two *Glaſs Planes* in the *Open Air* — and in *Vacuo* — between *Marble* and *Braſs Planes* in the *Open Air*. n. 319. p. 258.

21. The *Aſcent* of *Liquors* between two *Round Glaſs Planes* in the *Open Air*. *Ibid.* p. 265.

22. The *Aſcent* of *Water* through a *Tube* fill'd with *Aſhes* in the *Open Air* — and in *Vacuo*. *Ibid.* p. 262.

23. The *Aſcent* of *Liquors* in *Small Tubes* of *unequal Thickneſs*, but *equal Bores* or *Cavities*. *Ibid.* p. 260.

24. The *Aſcent* of various *Liquors* between two *Square Glaſs Planes*. *Ibid.* p. 266.

25. An Account of an *Experiment* concerning the *different Denſities* of the *Air*, from the greateſt Degree of *Heat* to that of *Cold* in our Climate. n. 315. p. 93.

26. An Account of an *Experiment* concerning the *different Weights* of the *ſame ſorts of Bodies*, but of very *unequal Surfaces* in *Water*, which were of *equal Weight* in *common Air*. n. 320. p. 306.

27. An *Experiment* concerning the *different Denſities* of *common Water* from the greateſt Degree of *Heat* in our Climate to the *Freezing* Point obſerv'd by a *Thermometer*. n. 319. p. 267

n. 319. p.269. 28. *Experiments* in relation to the *Weight* of *common Water* under *different* Circumſtances.

n. 320. p.302. 29. An *Experiment* concerning the *Freezing* of *common Water*, and *Water purg'd of Air.*

Ibid. p. 304. 30. An *Experiment* concerning the *Freezing* of common *Water*, ting'd with a Liquid, ſaid to be extracted from *Shell-Lac.*

n. 321. p.367. 31. An *Experiment*, ſhewing that *actual Sound* is *not* to be *tranſmitted* through a *Vacuum.*

Ibid. p. 369. 32. An *Experiment* concerning the *Propagation of Sound* paſſing from the ſonorous Body *into the common Air*, in *one Direction* only.

Ibid. p. 371. 33. An *Experiment* concerning the *Propagation of Sound* through *Water.*

n. 322. p.391. 34. An *Experiment*; ſhewing that an *Object* may become *Viſible* through ſuch an *Opake Body* as *Pitch* in the *Dark*, while it is under the Circumſtances of *Attrition* and a *Vacuum.*

n. 323. p.439. 35. An *Attempt* to produce *Light* on the Inſide of a *Globe Glaſs lin'd* with melted *Flowers* of *Sulphur.*

Ibid. p. 440. 36. A *Repetition* of the foregoing *Experiments*, &c.

n. 328. p. 196. 37. *Experiments* concerning the *Time* requir'd in the *Deſcent of Bodies* of *different* Magnitudes and Weights, *&c.*

Ibid. p. 199. 38. *Experiments* concerning the *Effects* of *Air* paſs'd *through red hot Metals*, &c.

n. 328. p.204. 39. A *Deſcription* of the *Apparatus* for making *Experiments* on the *Refractions of Fluids*; With a Table of the *Specific Gravities*, *Angles* of *Obſervations*, and *Ratio* of *Refractions* of ſeveral Fluids.

n. 331. p.325. 40. A *Repetition* of an *Experiment* of Dr. *Hook*'s, concerning *two Liquors*, which when *mix'd together poſſeſs leſs Space*, than when *Separate*; with another *Experiment* confirming the ſame.

Ibid. p. 328. 41. An Account of an *Experiment*, concerning an Endeavour to produce *Light* through a *Metallic Body*, under the Circumſtances of *Attrition* and a *Vacuum.*

n. 332. p.395. 42. An Account of an *Experiment* concerning the *Direction* of a *Drop* of the *Oil* of the *Oranges* between two *Glaſs Planes*, towards any ſide of them that is neareſt preſs'd together.

n. 333. p.431. 43. *Experiments* on keeping *Fiſhes* in *Water* under *different Circumſtances.*

n. 334. p.473. 44. Of the *Angle* requir'd to ſuſpend a *Drop* of the *Oil* of *Oranges*, at certain Stations, between two *Glaſs Planes*, plac'd in the Form of a *Wedge.*

n. 335. p.511. 45. The *Specific Gravities* of ſeveral *Metallic Cubes* in Compariſon with their *like Bulks* of *Water.*

n. 336. p.539. 46. An *Experiment* concerning the *Aſcent* of *Water* between two *Glaſs Planes* in an *Hyperbolic* Figure.

Ibid. p. 541. 47. A *Deſcription* of ſeveral *Strata* of *Earth*, *Stone*, *Coal*, &c. found in a *Coal-Pit* at the Weſt End of *Dudley* in *Staffordſhire*, by Mr. *Fettiplace*

tiplace Bellers, F. R. S. To which is added a Table of the *Specifick Gravity* of *each Stratum*, by Mr. *F. Hawkſbee.*

48. *Experiments* concerning the *Proportions* of the *Power* of the *Loadſtone* at *different Diſtances*; with a Deſcription of the Loadſtone made uſe of. n. 335. p. 505.

49. An *Experiment* concerning the *Proportions* of the *Aſcent* of *Spirit* of *Wine* between two *Glaſs Planes*, whoſe Surfaces were *plac'd* at *different Diſtances* from each other. n. 337. p. 151.

50. *Experiments* concerning the *Aſcent* of *Water* between two *Glaſs Planes* in an *Hyperbolic* Curve. *Ibid.* p. 153.

51. A farther Account of the *Aſcending* of *Drops* of *Spirit* of *Wine* between two *Glaſs Planes twenty Inches and a half long*; with a *Table* of the *Diſtances* from the *Touching Ends* and the *Angles* of *Elevation.* *Ibid.* p. 155.

CHAP. II.

Hydrology.

An Account of the Lake Vetter, *in* Sweden; *by Dr.* UrbanHearne. n. 298. p. 1938.

I. QUandoquidem admiranda nonnulla & inſolita de Lacu *Vettero Olaus Magnus*, aliiq; referant Scriptores; operæ pretium duxi in dicti *Lacus* indolem, & Scriptorum Fidem penitius inquirere: Inque iis quæ propriis Obſervationibus experiri non liceret, eorum indagare Teſtimonia, qui in Viciniâ habitantes, & antiquâ commendati fide, veris Narrationibus meis ſatisfacere poſſent Quæſtionibus.

Lacus *Vetteri* a Septentrione Meridiem uſque vergens de *Aſkerſundio Nericiæ* ad *Jonekopiam Smolandiæ* 14 *Suecica* metitur Milliaria, quorum quodlibet 5 vel 6 Milliaria *Anglica*, & decem unum fere conficiunt Gradum: Latitudine vero 3, nonnunquam vix 2 ſuperat Milliaria. Lacus ob elevatiores Montium colles, qui hunc in ipſo littore ſæpius ambiunt, nonnunquam paulo remotiores prominent, adſtantibus ſemper apparet ad latera depreſſus. Profunditate gaudet inſigni, adeo vero inæquali, ut aliquibus in locis ad 80, in confiniis vero *Oſtrogothiæ* diverſis, pauciſq; *Weſtrogothiæ* ad trecentas uſq; orgyas nullum reperias fundum. Civis quidam *Vadſtenenſis* Benedictus *Amberni*, qui ut ad littora Civitatis *Grennenſis Vetteri* exploraret profunditatem, aliquot Orgyarum funes, ſecuri loco ponderis appenſa, demiſerat, fundo autem nuſquam reperto, cum funes iterum collegerat, ſecuri deperditâ, cranium equi chordæ exactè alligatum obtinuit. Similis item abyſſus ad præcipitia montis *Ohmenſis*, quæ *parietis Occidentalis* nomine inſigniuntur,

niuntur, rimantium ſcrutinia ſemper illuſit ; ut ea propter non facile quiſquam his adpropinquare audeat metu Zephyri, qui ſubitò increſcens, anchoris nequidquam juvantibus quamvis undique jactis ad declivia montium navigia facile protrudit. Pariter ad *Weſtrogothiæ* quandam plagam olim Gubernator Comes *Johannes Oxenſtierna* projectis 300 orgyarum funibus nullum offendit fundum, prout hoc teſtantur piſcatores adhuc in vivis, quibus hoc negotii illo tempore committebatur. Limpida non minus quam profunda aquarum hæc eſt congeries, ut ad diſtantiam inſignem parvulus in fundo cernatur nummus. *Ericus Simonius* Paſtor & Præpoſitus *Vadſtenenſis*, album vel denarium 60 immerſum cubitis aere ſereniore ſe fatetur obſervaſſe. A ſuperficie autem remotior aqua aliqua quaſi viriditate tincta videtur : Et mirum ſane tot ſeſe in hanc exonerantes paludum, montium, ſylvarumque ſordes, limpidam hanc aquam ne leviter quidem inficere.

Amplitudine licet multos noſter ſuperet lacus, ut plurimum tamen a Scopulis immunis pauciſſimis gaudet inſulis. Quarum præcipua Comitum *Brakæorum* antehac ſedes *Viſingſoe* dicta, in medio aquarum *Grennam Smolandiæ* & *Weſtrogothiam* interjacet, prout ad boream inſula *Roknenſis* Acidulis *Medevienſibus* e regione eſt oppoſita. Apparent & aliæ ad littora ſitæ inſulæ, pauciſſimæ tamen æque ac parvæ. Cum vero ventis ſic libere expoſitus, proceris undique cingatur *Vetterus* montibus, nil mirum raro eundem quieſcere, ſed procellis ſæpius agitatum, altioribus arctiſque fluctibus navigantium cymbas vehementer concutere ; idque adeo ſæpe inopinatò, ut aquis inſtar ſpeculi quietis tectè commoveri incipiat, antequam vel minima aeris ventilatio ſentiatur. Quod efficere videtur tempeſtas, ſub aquis aliunde oriunda, ſenſim eundem protrudens, priuſquam ventorum turbines eouſque potuere derivari. Haud enim in *Vettero* infrequens furentibus ventis ferri navigia in uno loco, cum alia in confiniis ob tranquillitatem aeris remis propelli cernuntur. Indicio minime fruſtraneo a ventis ſubterraneis irruptiones ejuſmodi aquarum abunde promoveri eodem plane modo, atque ſimiles effectus explicare conatur *Varenius* in Geograph. Univerſ. Confirmant has ſuſpiciones Phænomena diverſa. Imminente enim Tempeſtate imbribuſque ululatus vel tonitru aquarum aere adhuc ſereno percipiuntur, quod mihi ipſi ad *Medevienſes* Acidulas, aurâ etiamnum placidiſſimâ non raro audire contigit ſubſequente ſemper turbine procelloſo. Manifeſtius adhuc hoc experiuntur incolæ *Viſingſoenſes*, quibus ab illo tractu inſulæ, unde die poſteriori venti oriuntur, inſtar ictuum tormentorum aures confuse vellicantur. Cumque ad orientem ejuſmodi rugitus deprehenduntur, ut plurimum cum grandine & pluviis excitari ſolet Eurus. Conſideratione etiam dignæ variæ illæ ſunt ſufflationes, vaporum ſubitaneæ elevationes, & confeſtim proſilientes halitus, quos in hoc lacu nonnulli obſervavere. Non abſque admiratione tale quid cum Sociis animadvertit Architectus *Abraham Winandz* qui has oras aliquando præ-

præteriens, aquis tum maxime quieſcentibus, ſtrictim hinc inde inſtar telorum e fundo ejaculari nubeculas conſpexit, qui deinceps fumi in aere ſeſe jungentes, levibus pluviis toto die peregrinantes infeſtarunt, quæ omnia ventorum ſubterraneorum præſentiam non incertè arguunt.

Idem procul dubio ventus, cum ſuperius adveniente procella in cauſa eſt, quod cum tempore verno glacies adhuc valida & ſpiſſa hac hora equis trahiſque ſuſtinendis abunde ſufficiat, alterâ, glacie evaneſcente ejuſdem ruptum per totum lacum repente adeo contingat, ut qui paulo ante equis ſecurè vehebatur, jam aqua undique patente ibidem placidè queat navigare. Antequam verò ejuſmodi metuenda irruptio, ſtupendus qui præcedit aquarum rugitus viatoribus fugam cum terrore ſuadet, qui tamen a littore aliquando remotiores, vel aquis extemplò immerguntur, vel ſuper glaciei fragmenta morti vicini aliquamdiu vagari coguntur. Nonnunquam abrupte fundum petit glacies aere vel minime commoto.

Num vero ſubterraneis ejuſmodi ventis excitandis metallici inſerviant halitus, in medio relinquo. Eos vero illic loci neutiquam deficere evincunt varii ad *Vetteri* boreales *Nericiæ Weſtrogothiæque* plagas ſiti montes, venis Martialibus, fortaſſe & metallicis nobilioribus nuperius detectis, aliiſque mineralium ſpeciebus diverſis, Antimonio videlicet, Magneſia, Calce, Mica ſterili, Galenæ ſpeciebus Ochra Pyriteque opulenter referti, unde Sulphur, Vitriolum, Alumen aliique ſucci minerales elici alioqui conſuevere. Quin in ipſis pariter aquis, non minor Pyritis quantitas quam Ochræ cujuſdam ferruginoſæ copioſa reperitur congeries. Huc ignis referendus eſt fatuus, non ad littora ſolum frequenter obſervatus, ſed tempore nocturno in mediis aquis volitare & piſcatores confundere viſus. Quem creſcentibus metallicis ſulphureiſque deberi halitibus plurimis eſt perſuaſum. Nec ſine Vaporum mineralium ope Granati, Porphyrii, Jaſpides, Chryſtalli, ſelectique alii generantur in hoc lacu lapides, qui a Comite *Petro Brahco* olim collecti, & ad tantum redacti fuere nitorem, ut inter ornamenta Sponſarum etiamnum *Viſingſburgi* adhibeantur : Quæ omnia metallicam agnoſcunt proſapiam, ut *Vettero* propinquas *Medevienſes* taceam Acidulas.

Inter reliquas noſtri lacus proprietates admirationem ſane non effugiunt inſignes ſub aquis vortices, torrenteſque pertinaces, qui in hoc unico licet gaudentes oſtio ventis fluctibuſque directe obverſi piſcatoribus non leve faceſſunt negotium. Suſpicio hinc enata ob profunditatem inexhauſtam, & clam ruentes alveos ventoſque ſub terra genitos, aliquam huic *Vettero* cum alio ab hoc ad occidentem X milliaribus *Suecicis* diſtante *Vennero* ſub tellure eſſe communicationem. Nec aliter ſuadent diverſæ voragines hos lacus interjacentes, quarum duas paræciæ *Fægrenſis* voraginum albæ & nigræ nomine inſignitas, metiri curavit D. *Haddorphius*. Altitudinis vero deprehendit immenſæ, motumque

que in his obſervavit inteſtinum, ac ſi fermento turgidæ extitiſſent. Eidem opinioni favet, quod abſq; causâ manifeſtâ certis annis augeatur noſtra aqua, cum ſequentibus notabiliter iterum decreſcat. Animadvertit Paſtor *Motalenſis* Dominus *Daniel Rydelius* præteritis hiſce ſeptem Annis, certis quibuſdam in locis ſenſim adeò evanuiſſe *Vetterum*, ut ad aliquot orgyas ſicco pede illuc ambulare potuerit quo cymbis antea vehi cogebatur, pluvia interea temporis, annis videlicet 1680, 1682, 1684 & 1685 undiq; abundante. Anno verò 1686 verſus autumnum aqua paulatim iterum cernebatur augeri ad hunc uſq; annum 1688. An vero ſtata ſic ſervet tempora noſter lacus, ac *Vennerum* ſingulis ſeptem annis accreſcere ſeptemq; viciſſim diminui ejus rimatores contendunt, de hoc certi quid determinare nequeo. Admiratione itidem eſt dignum, aere ſereno tormentorum ibidem ſentiri exploſiones, *Holmiæ* aliiſque in locis ad 30 milliaria diſtantibus inſtitutas. Ut cum Anno 1685 Regii Principes *Holmiæ* ſepelirentur horâ quintâ quilibet ictus exacte perciperetur. Pari facilitate tela Anno 1676 in pugna navali exploſa ad 30 circiter milliaria diſtinctè fuere obſervata.

Quæ verò de *Gilberti Speluncâ* in inſula *Viſingſuenſi*, *Olaus Magnus*, *Meſſenius* aliique hiſtorici referunt, auctorum ſint relicta fidei. Hoc equidem conſtat reperiri adhuc cavernam & quidem fœtore refertam ſulphureo & nauſeabundo, quem aſſentientibus accolis ipſi ſpeluncæ prope aquas in paludæ ſitæ & collecto per longius tempus ſqualori, ſulphureos, uvidoſque exhalanti Vapores aſcribendum cenſeo. Adparere interim in confiniis diverſa ſpectra & phantaſmata, quæ ut plurimum fæminarum, aliquando equorum vel alius animalis ludicrâ ſpecie ſeſe ſiſtunt, nemo hiſce curioſitatibus intentus inficiabitur. Evincerent hoc ipſum diverſæ vetuſtioris æque ac recentioris ævi hiſtoriæ, niſi obiter hæc decreviſſem peſtringere.

Nec ſilentio præteriri debet celebris iſte amnis *Motala*, qui unicum uti dictum *Vetteri* noſtri oſtium, certis temporibus fluiditatem quaſi deponere, & in decurſu adeo ſolet ſiſti, ut liberè hunc ingredi, piſceſque in fundo relictos abſque impedimento capere nonnunquam fuerit conceſſum. Prout Anno 1682 & 1685 tempore *Natalitiorum Chriſti* idem eveniſſe conſtat. Vulgo & accolis unanimiter eſt perſuaſum impune nunquam Fluminis retardationem contingere, niſi vel caritatem annonæ ingentem, vel Bellum, vel qualecunque publico præſagiat detrimentum, æque ac Balænarum in *Tameſin* ingreſſus *Anglis* fatale quid portendere perhibetur. Mihi vero ut Phyſico, naturales mirandorum effectuum cauſas unicè inquirenti quibuſcunque narrationibus ſatisfieri non potuit, niſi naturæ legibus eaſdem deprehenderim conformes. Sollicitus idcirco in iis fui examinandis, quæ lucem huic Phænomeno fœnerari videbantur, licet fluminis retardationem coram ſpectare nunquam licuerit. Utut vero varie hanc rem explicare conantur huic amni vicini, illo inſtanti aquas a littoribus recedentes

fundum

fundum petere rati, ſemper tamen ſuſpicio mihi oborta fuit, vel glacie, vel nive fluminis infima obſtructa, munimentum aquis præbuiſſe inferioribus interea ſeſe in Mare exonerantibus. Anſam huic opinioni dedit, quod nunquam vere, Æſtate vel Autumno, ſed ſemper tempore *Natalitiorum Chriſti* vel novi Anni iſthæc contigerit mutatio; & quod prope pontem ſemper contigerit, ubi aquis ultra tres ulnas minimè profundis, aggerum lapidumq; acervi quibus Pons innititur, fluminis decurſum refrænant. Hanc ſuſpicionem veritati conſonam teſtatur propriâ & aliorum experientiâ ſuffultus Paſtor Eccleſiæ *Motalenſis* in limine pontis habitans, qui herbas longiores, ut Potamogeiton, Polygonum aquaticum, &c. a ponte ad propinquos anfractus in aquis germinare aſſeruit, & his glaciem ſtriarum inſtar & nivis congelatæ adhærere, quæ à flumine detruſa & in pontis fundamenta delata tractu temporis cumulari & toto amni ſiſtendo ſufficere poteſt. Fatentur pariter molitores ibidem habitantes, imminente fluxus cohibitione, niveas quaſi moles è lacu derivari, quæ corpori, cui impingunt, inſtar glutinis adhærentes, fundum ſenſim petunt. Nec infrequens aquas per totum lacum uno die æqualiter quietas, altero irritatas prope pontem ſiſti. Quidquid verò ſit mirationem adhuc ſubit, non hyeme intenſiſſimo, ſed aere clementiore, & quidem ut plurimum circa ferias Natalitias, & novum annum contingere. Frigus fortè ſub aquis adhuc viget, licet in aere ceſſaverit, vel glacies debiliùs congelata herbis aliiſq; impedimentis detenta, obſtructiones haſce parit.

Some Particulars of a Fountain near the Lake Vetter.

Silentio autem neutiquam præterire poſſum ea quæ de fonte quodam non longè à *Vetteri* littore in paræcia *Nyenſi* (ubi & Acidulæ *Medevienſes)* prope Templum & Paſtoris ædes ſito, ex ingenua parochi digniſſimi D. *Jonæ Frodelii* aliorumq; relationibus haurire licuit. Eſurinum hunc fontem vel annonæ appellitant vatem, eò quod nunquam aquâ ſufficienter repleatur, niſi annonæ ſuccedat ſequente Anno caritas. Ambiunt hunc fontem undiq; colles arenoſi molliores. Interjacet hos vallis depreſſa, ſed minimè paludoſa. Ex hac occultis meatibus hæc Scaturigo promanat, in eo ſingulare quid obtinet, quod Æſtate pluviis abundante ut plurimum evadat aridus, cum viciſſim æſtatibus ſicciſſimis, inſtante fame, ut & ſecundum alios (quos attingere non vacat) bello, Regiam *Motalenſem Vadſtenenſemq*; viam inundet, prout multorum ibi habitantium evincunt teſtimonia. Anno 1685 pluviis & imbribus frequentiſſimo, penitus hic fons exaruit, nec ultra dimidium pedem ſqualida. Anni 1686 æſtate aqua accreſcere viſa eſt. Nec veritatem hujus narrationis in dubium revocare præſentis anni permittit ſicciſſima æſtas, qua cum aquis penitus vacui evaſerunt fontes vicini omnes, hic aquâ quam maximè abundavit. Præcipue vero obſervatu digna ſunt,

1. Soli

1. Soli *Oſtrogothiæ* ex locis fonti proximioribus annonæ denunciari caritatem.
2. In totâ hac Regione fontiſque præcipuè viciniâ arenoſum eſſe campum, parte etiam aliquâ limo duriore gaudente, quibus impregnandis ſufficiens ſemper requiritur lympha; proinde etiam,
3. Deficere ibidem ſegetes non niſi in ficcioribus annis, cum contrarium obtineat *Iemptia*, aliæque provinciæ nonnullæ ſeptentrionales.
4. Meteororum tempeſtatiſq; proventum, terræ & quidem ſub ſuperficie latentis aliquando ſequi indolem.
5. Prope colles arenoſos venis non patentibus per ſabulum quaſi colaturâ trajectas colligi aquas hujus ſcaturiginis.
6. Phyſicas ob cauſas imminente tempeſtate ficciore, augeri vel aſcendere poſſe eas aquas, pluviosâ iterum decidere, quæ prolixius deducere alterius erit temporis & inſtituti.

A New Contrivance *for* Diving, *&c. by Dr.* E. Halley. 349. p. 492.

II. Many Methods have been propoſed, and many Engines contriv'd, for enabling *Men* to abide a competent while under *Water*: And the reſpiring freſh *Air* being abſolutely neceſſary to maintain Life in all that breathe, ſeveral Ways have been thought of for carrying this down to the *Diver*, who muſt, without being ſupply'd therewith, return very ſoon, or periſh.

We have heard of *Divers* for Spunges in the *Archipelago*, helping themſelves by carrying down *Spunges* dipp'd in Oil in their Mouths; but conſidering how ſmall a Quantity of *Air* can be ſuppos'd to be contain'd in the Interſtices of a *Spunge*, and how much that little will be contracted by the Preſſure of the *incumbent Water*, it cannot be believ'd that a Supply, by this Means obtain'd, can long ſubſiſt a Diver. Since by Experiment it is found that a Gallon of Air included in a Bladder, and by a Pipe reciprocally inſpir'd and expir'd by the Lungs of a Man, will become unfit for any further Reſpiration, in little more than one Minute of Time; and though its Elaſticity be not much alter'd, yet in paſſing the Lungs, it loſes its vivifying Spirit, and is render'd Effete, not unlike the Medium found in Damps, which is preſent Death to thoſe that breathe it; and which, in an Inſtant, extinguiſhes the brighteſt Flame, or the ſhining of glowing Coals, or red hot Iron, if put into it. I ſhall not go about to ſhew what it is the Air loſes by being taken into the Lungs, or what it communicates to the Blood by the extreme Ramifications of the *Aſpera Arteria*, ſo intimately interwoven with the Capillary Blood-Veſſels; much leſs to explain how it is perform'd, ſince no Diſcovery has been made to prove that the ultimate Branches of the Veins and Arteries there, have any *Anaſtomoſes* with thoſe of the *Trachæa*; as by the Microſcope they are found

found to have with one another. But I leave this to the Anatomiſts; and only conclude from the aforeſaid Experiment, that a naked Diver, without a Spunge, cannot be above a couple of Minutes inclos'd in Water, (as I once ſaw a *Florida-Indian* at *Bermudas*) nor much longer with a Spunge, without Suffocating; and not near ſo long without great Uſe and Practice: Ordinary Perſons generally beginning to ſtifle in about half a Minute of Time. Beſides, if the Depth be conſiderable, the Preſſure of the Water on the Veſſels is found by Experience to make the Eyes Blood-ſhot, and frequently to occaſion ſpitting of Blood.

When therefore there has been Occaſion to continue long under Water, ſome have contriv'd double flexible Pipes to circulate Air down into a Cavity encloſing the Diver, as with Armour, to bear off this Preſſure of the Water, and to give Leave to his Breaſt to dilate upon Inſpiration: The freſh Air being forc'd down by one of the Pipes with Bellows, or otherwiſe, and returning by the other of them, not unlike to an Artery and Vein. This has indeed been found ſufficient for ſmall Depths, not exceeding twelve or fifteen Foot: But when the Depth ſurpaſſes three Fathoms, Experience teaches us, that this Method becomes impracticable: For though the Pipes and the reſt of the *Apparatus* may be contriv'd to perform their Office duly, yet the Water (its Weight being now become conſiderable) does ſo cloſely embrace the Limbs that are bare, or cover'd with a flexible Covering, that it obſtructs the Circulation of the Blood in them; and preſſes with ſo much Force on all the Junctures, where the Armour is made tight with Leather, Skins, or ſuch like, that if there be the leaſt Defect in any of them, the whole Engine will inſtantly fill with Water, which will ruſh in with ſo much Violence, as to endanger the Life of the Man below, who may be drown'd before he can be drawn up. Upon both theſe Accounts, the Danger encreaſes with the Depth. Beſides, a Man thus ſhut up in a weighty Caſe, as this muſt needs be, cannot but be very unweildy and unactive, and therefore unfit to execute what he is deſign'd to do at the Bottom.

To remedy theſe Inconveniences, the *Diving-Bell* was next thought of; wherein the *Diver* is ſafely convey'd into any reaſonable Depth, and may ſtay more or leſs Time under Water, according as the *Bell* is of greater or leſſer Capacity. This is moſt conveniently made in the Form of a Truncate Cone, the ſmaller Baſis being clos'd, and the larger open; and ought to be ſo poiz'd with Lead, and ſo ſuſpended, that the Veſſel may ſink full of Air, with its greater or open Baſis downwards, and as near as may be in a Situation parallel to the Horizon, ſo as to cloſe with the Surface of the Water all at once. Under this Couvercle the Diver ſetting, ſinks down together with the included Air; and if the Cavity of the Veſſel may contain a Tun of Water, a ſingle Man may remain there-

therein at leaſt an Hour, without much Inconvenience, at five or ſix Fathoms deep. But this included Air, as it deſcends lower, does contract itſelf according to the Weight of the Water that compreſſes it; ſo that at thirty three Foot deep or thereabouts, the Bell will be half full of Water, the Preſſure of it being then equal to that of the whole Atmoſphere: And at all other Depths, the Space occupied by the compreſs'd Air in the upper Part of the Bell, will be to the under Part of its Capacity fill'd with Water, as thirty three Feet to the Depth of the Surface of the Water in the Bell below the common Surface thereof. And this condens'd Air, being taken in with the Breath, ſoon inſinuates itſelf into all the Cavities of the Body, and has no ſenſible Effect, if the Bell be permitted to deſcend ſo ſlow as to allow Time for that Purpoſe. The only Inconvenience is found in the Ears, within which there are Cavities opening only outwards, and that by Pores ſo ſmall as not to give Admiſſion even to the Air itſelf, unleſs they be dilated and diſtended by a conſiderable Force. Hence on the firſt Deſcent of the Bell, a Preſſure begins to be felt on each Ear, which by Degrees grows painful, like as if a Quill were forcibly thruſt into the Hole of the Ear; till at length the Force overcoming the Obſtacle, that which conſtringes theſe Pores yields to the Preſſure, and letting ſome condens'd Air ſlip in, preſent Eaſe enſues. But the Bell deſcending ſtill lower, the Pain is renew'd, and again eas'd after the ſame Manner. But when the Engine is drawn up again, the condens'd Air finds a much eaſier Paſſage out of thoſe Cavities, and even without Pain. This Force on the auditory Paſſages might be ſuſpected to be prejudicial to the Organs of Hearing, but that Experience teaches otherwiſe. But what is more inconvenient in this Engine, is, the Water entering into it, ſo as to contract the Bulk of Air (according to the aforeſaid Rule) into ſo ſmall a Space, as that it ſoon heats and becomes unfit for Reſpiration, for which Reaſon it muſt be often drawn up to recruit it: And beſides the Diver being almoſt cover'd with the Water thus entering into his Receptacle, will not be long able to endure the Cold thereof.

To obviate theſe Difficulties which attend the Uſe of the common Diving-Bell, I have thought of Means to convey Air down to it, whilſt below; whereby not only the Air included therein, would be refreſh'd and recruited, but alſo the Water wholly driven out, in whatever Depth it is; and will furniſh Air at the Bottom of the Sea in any Quantity deſir'd. The Deſcription of my *Apparatus* take as follows:

The Bell I made uſe of was of Wood, containing about ſixty Cubick Foot in its Concavity, and was of the Form of a Truncate Cone, whoſe Diameter at Top was three Foot, and at Bottom five. This I coated with Lead ſo heavy, that it would ſink empty, and

I distributed the Weight so about its Bottom, that it would go down in a perpendicular Situation, and no other. In the Top, I fix'd a strong, but clear Glass, to let in the Light from above; and likewise a Cock to let out the hot Air that had been breath'd; and below, about a Yard under the Bell, I plac'd a *Stage* which hung by three Ropes, each of which was charg'd with about one hundred Weight, to keep it steady. This Machine, I suspended from the Mast of a Ship, by a *Spritt*, which was sufficiently secur'd by *Stays* to the Mast-head, and was directed by *Braces* to carry it over board clear of the Ship side, and to bring it again within board.

To supply Air to this Bell when under Water, I caus'd a couple of Barrels, of about 36 Gallons each, to be cas'd with Lead, so as to sink empty, each having a Bung-hole in its lowest Part, to let in the Water, as the Air in them condens'd on their Descent; and to let it out again, when they were drawn up full from below. And to a Hole in the uppermost Part of these Barrels, I fix'd a Leathern Trunk or Hose, well liquor'd with Bees-Wax and Oil, and long enough to fall below the Bung-hole, being kept down by a Weight appended; so that the Air in the upper Part of the Barrels could not escape, unless the lower Ends of these Hose were first lifted up.

I fitted these Air-Barrels with Tackle proper to make them rise and fall alternately, after the Manner of two Buckets in a Well; which was done with so much Ease, that two Men, with less than half their Strength, could perform all the Labour; and in their Descent they were directed by Lines fasten'd to the under Edge of the Bell, which pass'd through Rings plac'd on both Sides the Leathern Hose in each Barrel; so that sliding down by those Lines, they came readily to the Hand of a Man, who stood on the Stage on purpose to receive them, and to take up the Ends of the Hose into the Bell. Through these Hose, as soon as these Ends came above the Surface of the Water in the Barrels, all the Air that was included in the upper Parts of them, was blown with great Force into the Bell, whilst the Water enter'd at the Bung-holes below, and fill'd them: And as soon as the Air of one Barrel had been thus receiv'd, upon a Signal given, that was drawn up, and at the same Time the other descended; and by an alternate Succession furnish'd Air so quick, and in such Plenty, that I my self have been one of five, who have been together at the Bottom, in nine or ten Fathoms Water, for above an Hour and half at a Time, without any Sort of ill Consequence: And I might have continu'd there as long as I pleas'd, for any Thing that appear'd to the contrary. Besides the whole Cavity of the Bell was kept entirely free from Water, so that I sat on a Bench, which was diametrically plac'd near the Bottom, with all my Cloaths on. I only observ'd, that it was ne-

ceſſary to be let down gradually at firſt, as about 12 Foot at a Time; and then to ſtop and drive out the Water that enter'd, by receiving three or four Barrels of freſh Air, before I deſcended farther. But being arriv'd at the Depth deſign'd, I then let out as much of the hot Air that had been breath'd, as each Barrel would repleniſh with cool, by means of the Cock at the Top of the Bell; through whoſe Aperture, though very ſmall, the Air would ruſh with ſo great Violence, as to make the Surface of the Sea boil, and to cover it with a white Foam, notwithſtanding the great Weight of Water over us.

Thus I found I could do any Thing that was requir'd to be done juſt under us; and that, by taking off the Stage, I could, for a Space as wide as the Circuit of the Bell, lay the Bottom of the Sea ſo far dry, as not to be over Shoes thereon. And by the Glaſs Window ſo much Light was tranſmitted, that, when the Sea was clear, and eſpecially when the Sun ſhone, I could ſee perfectly well to write or read, much more to take up any Thing that was under us: And by the Return of the Air Barrels, I often ſent up Orders, written with an Iron Pen on ſmall Plates of Lead, directing how to move us from Place to Place. At other Times, when the Water was troubled and thick, it would be as dark as Night below; but in ſuch a Caſe, I have been able to keep a Candle burning in the Bell as long as I pleas'd, notwithſtanding the great Expence of Air requiſite to maintain Flame.

I take this Invention to be applicable to various Uſes; ſuch as *Fiſhing* for *Pearl*, *Diving* for *Coral*, *Spunges*, and the like, in far greater Depths than has hitherto been thought poſſible: Alſo for the fitting and plaining of the Foundations of Moles, Bridges, *&c.* upon rocky Bottoms; and for the cleaning and ſcrubbing of Ships Bottoms when foul, in calm Weather at Sea.

By an additional Contrivance, I have found it not impracticable for a Diver to go out of this Engine to a good Diſtance from it, the Air being convey'd to him with a continu'd Stream, by ſmall flexible Pipes; which Pipes may ſerve as a Clue to direct him back again, when he would return to the Bell.

Of an Eruption *of* Waters *in* Yorkſhire, *by Mr.* R. Thoresby. n. 306. p. 2236.

III. I have lately enquir'd of a Neighbour concerning the extraordinary Eruption of Waters at *Craven*, which the Vicar of *Kildnick* ſent (†) an Account of to the *Royal Society*: I am not only fully ſatisfied of the Truth of what Mr. *Pollard* ſays, but alſo, that, as he conjectures, a great Part of the Land is not to this Day recover'd from the Sand and Stones, though a great Number of People were employ'd about it. Upon the *opening of the Rock*, at the Foot of which the Town of *Starbotham* ſtands, the Water guſh'd out in ſo vaſt a Quantity, as if it would have ſwept away the whole Town. The Wa-

(†) *Vid.* Supra V. II. C. II. S. XXXIV.

Waters came rolling impetuouſly down, almoſt at once ; ſeveral Houſes were utterly ruin'd, and others wreck'd up to the Chamber Windows ; one, particularly, was ſo cover'd, that a great Piece of the Rock was left upon the Top of the Chimney. My Neighbour was an Eye-witneſs of this ſad Accident, and has ſpent much Time in clearing ſome Part of his Land.

Of Inundations *in* Ireland, *by Mr.* Neve. n. 320. p. 309.

IV. On *October* the *7th*, 1706, after a very rainy Day, and ſouth-erly Wind, there happen'd a prodigious Flood in the North of *Ireland* (the like not in the Memory of Man) which broke down ſeveral Bridges, and the Sides of ſome of the Mountains. It came running down in vaſt Torrents from the Mountains, and drown'd abundance of black Cattle and Sheep, ſpoil'd a great deal of Corn and Hay in the Stacks ; it laid abundance of Houſes two or three Feet deep in Water, and broke down ſeveral of the Forges and Mill-Dams.

On *July 3d*, 1707, there happen'd another *Flood*, which came ſo ſuddenly from the Mountains, as if there had been ſome ſudden Eruption of the Waters. And on the *26th* of the ſame Month, in the County of *Antrim*, there happen'd a very ſudden and ſurprizing *Flood*, which rais'd the *Six-Mile-River* at that Rate, that it broke down two ſtrong Stone Bridges, and three Houſes, and carried away 600 Pieces of Linnen Cloath that lay bleaching, fill'd ſeveral Houſes ſeveral Feet deep with Water, tore down ſome large Rocks in its Paſſage, and left ſeveral Meadows cover'd a Foot or two deep with Sand. In the South-Eaſt Part of the County of *Derry*, they had that Day but little Rain, with ſome Thunder ; but beyond the Mountains, in the North-Weſt Part of the County, the River *Roe* had a great Flood.

Obſervations *on the Lake* Lough-Neagh *in* Ireland, *by Mr.* F. Neville. n. 337. p. 260.

V. There is no petrifying Quality in the Water of the Lake *Lough-Neagh*, as ſome believe ; I have liv'd 14 Years at *Dungannon*, within five Miles of it, and have been often there about the Skirts for many Miles, and in a Boat upon it ſeveral Times ; I have view'd it often when the Waters have been very low, and a large Strand left in ſeveral Places : And many Trees lay in the Verge of the *Lough* (of which, I believe, ſome might have lain there ſome hundreds of Years) which had been over-turn'd by the *Lough*'s encroaching on the Land, where great Woods had grown ; and many Roots of great Trees were ſtanding in their proper Places, where the Water had prevail'd on the Land ; and I perceiv'd no Alteration in the Wood at all, but it was firm, ſound Wood, without any Petrifaction.

Mr. *Brownlow* told me, that he had drove ſeveral Holly Stakes into

the Ground within the Verge of the *Lough*, and that ſome of them continu'd there many Years, but that he found no Alteration.

There has indeed been great Quantities of ſuch ſort of Stone, like to Wood, found upon the Strand after great Floods and Storms of Wind, which have put the *Lough* into a Ferment; the Waves breaking down the Banks, encroaching on the Land, and tumbling over Trees, by which Encroachment this Sort of Stones are diſcover'd: And if ever they were Wood, they were petrify'd by the Earth, and not by the Water; of which kind I have ſeen ſeveral Pieces big and little, ſome like Oak, ſome Aſh, and ſome like Holly, with Bark, Grain, and Knots, like Wood; ſo that any by the Eye would judge it Wood, till they come to try it. I had a Piece about ſixteen Inches long, that look'd as if it had been a great Chip cut out of the Side of an Oak Block, with the Bark on it; and in cutting ſuch large Chips, there happens generally ſuch Shakes and Flaws, ſo that there will be a Separation of Parts at one End, and they remain firm at the other, as it was in this. I could have rais'd ſeveral of ſuch Splinters, of this large Chip, ſome bigger, and ſome leſs; and when ſo rais'd, they would have ſlapp'd down as though they were a Spring. Some of thoſe Stones would appear at one End as if rotten, and decay'd Wood; but trying it, it was as much Stone, as any other Part.

The Lake is reputed to be twenty four Miles long, and twelve Miles broad, and Navigable from *Charlemount* to *Portlenoue*, which is about thirty five Miles. It does not abound with many Sorts of Fiſh; but, thoſe that are, are very good; ſuch as Salmon, Trout, Pike, Breame, Roach, Eels, and *Pollans*, with which laſt, it does abound. The *Engliſh* call them *Freſh-water Herrings*. They catch them in the Summer with Sieves, as they do Herrings. They are much in Shape and Bigneſs like to the largeſt Smelts, full of very large bright Scales, and pleaſant Meat, being eat freſh. Theſe were ſuppos'd to be a Fiſh peculiar to that Lake; but ſince I came here, I find *Lough Earne* has the ſame Sort, but not in ſo great a Plenty. They are generally caught here in their Eel-Nets, running to the Sea; ſo that I am of Opinion, that they are that Sort of Fiſh that is caught in the Sea, or between the freſh and ſalt Water, call'd *Shads*; and that the large ones come from the Sea, as the Salmon doth, and leave their Spawn in the *Lough*; which, when they grow to be big, go to the Sea, and there come to their full Growth: And that which confirms me in my Opinion, is, that at the Salmon Fiſhing at *Colraine*, they catch many of the large ones going up to the *Lough*. There is one ſort of Trout in *Lough-Neagh* very large: I have ſeen one weigh 30 Pound weight; and the largeſt Salmon that I ever ſaw, weigh'd not more than 35. This ſort of Trout the *Iriſh* call a *Budagh*.

Fiſh Pollans.

That

That there is ſome healing Quality in the Water of this *Lough* is certain; but whether diffus'd through all Parts thereof is not known, nor pretended. The *Fiſhing Bay*, which is about half a Mile broad, hath a fine ſandy Bottom, where any one may walk with Safety and Eaſe from the Depth of his Ankle to his Chin, upon an eaſy Declivity, at leaſt three hundred Yards before a Man ſhall come to that Depth. Others, as well as myſelf, have obſerv'd, that the Bottom has chang'd from Cold to Warm, and from Warm to Cold, and this in different Spots through the Bay.

The firſt Occaſion of taking Notice of this Bay for Cure, was in the Reign of King *Charles* the Second: There was one Mr. *Cunningham*, who had an only Son grown to Man's Eſtate. This young Man had the Evil to that Degree, that it run upon him in eight or ten Places: He had been touch'd by the King, and all Means imaginable had been us'd for his Recovery; but all did no good, and his Body was ſo waſted, that he could not walk. When all Hopes of his Recovery were paſs'd, he was carried to the *Lough*, where he was waſh'd and bath'd; and in eight Day's Time, bathing each Day, all the Sores were dry'd up, and he was cur'd, and grew very healthy, married, begot Children, and liv'd nine or ten Years after. This Account I had from Capt. *Morris*, and his Brother, who were Eye-Witneſſes. After ſo remarkable a Cure, many came there, who had running Sores upon them, and were cur'd after a little Time. The Natives thought it could not do well, but upon ſome particular Time appropriated for that Service; and now great Crowds come there on *Midſummer-Eve*, of all ſorts of Sick; and ſick Cattle are brought there likewiſe, and driven into the Water for their Cure; and People do believe they receive Benefit. I know it dries up running Sores, and cures the Rheumatiſm, but not with once bathing, as People now uſe it; and the drinking the Water, I am told, will ſtop the Flux. I look upon it to be one of the pleaſanteſt Bathing Places I ever ſaw.

Of the Eruption *of a* Burning Spring *in* Shropſhire, *by Mr.* R. Hopton. n. 334. p. 475.

VI. About *June* 1711, at *Broſely* near *Wenlock* in *Shropſhire* (about two Nights after a remarkable Day of Thunder) there was heard a terrible Noiſe in the Night, which awaken'd ſeveral People; who riſing to ſee what it was, came at laſt to a Boggy Place under a little Hill, acout 200 Yards off the River *Severn*; where they perceiv'd a mighty Rumbling and Shaking in the Earth, and a little boiling up of Water through the Graſs: They took a Spade, and digging up ſome Part of the Earth, immediately the Water flew up to a great Height, and a Candle, that they had, ſet it on Fire.

To prevent the Spring being deſtroy'd, there is an Iron Ciſtern plac'd about it, with a Cover upon it to be lock'd, and a Hole in the Middle thereof; that any who come may ſee the Water thro':

If

If you put a lighted Candle, or any Thing of Fire to this Hole, the Water immediately takes Fire, and burns like Spirit of Wine, and continues to do ſo as long as you can keep the Air from it; but by taking up the Cover of the Ciſtern it quickly goes out: The Heat of this Fire much exceeds the Heat of any Fire I ever ſaw, and ſeems to have more than ordinary Fierceneſs with it.

Some People out of Curioſity, after they have ſet the Water on Fire, have put a Kettle of Water over the Ciſtern, and in it Green Peaſe, or a Joint of Meat, and boil'd it much ſooner than over any Artificial Fire that can be made. If any green Boughs, or any Thing elſe that will burn, is put upon it, it preſently conſumes them to Aſhes.

The Water of itſelf is as cold as any Water I ever felt; and what is remarkable, as ſoon as ever the Fire is out, if you put your Hands into it, it feels as cold as if there had been no ſuch Thing as Fire near it. It ſtill [in *September*] continues boiling up with a conſiderable Noiſe.

Of a Mineral Water *at* Canterbury, *by Dr.* Moulins. n. 312. p. 2462.

VII. About twelve Years ago a *Mineral Water* was accidentally diſcovered in *Canterbury*. In digging the Ground, they firſt met with a black fat Mold, extending itſelf three Foot deep, and gradually changing into another Sort of Earth, very fat, and like Butter. This ſecond Lay was two Foot thick; the Colour of it Yellow, ſomething mix'd; its Odour ſtrong and Mineral; and a Piece of it being for ſome Time expos'd to the Sun, ſmell'd much like burning Sulphur. After this they found a Quickſand of a darker Colour than the firſt Earth, mix'd with ſeveral little Stones, and the Smell ſtronger than before. Two Foot further, under the Quickſand, a hard Rock appear'd, out of which Water guſh'd with ſome Violence. They dug two Wells at about ſeven Feet diſtance from each other; one about eight or nine Feet from its Surface, and twelve from the Surface of the Ground about it, and reacheth the Rock: The other is not ſo deep by two Feet, and only toucheth the Sand. This laſt is ſomething ſtronger of the Sulphur, but the other is ſtronger of the Mineral Spirit and ferruginous Parts.

Two Drams of the ſecond Lay of Earth, found in digging, being put into four Ounces of Spirit of Vinegar, there preſently aroſe a conſiderable Ebullition; and ſoon after the Spirit was ting'd with a yellow browniſh Colour, which ſuffer'd no Alteration with the Infuſion of Logwood, nor with Galls, but with Oil of *Tart. p. deliq.* turn'd greeniſh, and with the Infuſion of *Lig. neph.* of a pale Red.

The Water taken up at the Spring is extraordinary limpid, but grows ſomething whitiſh in a quarter of an Hour, and in half an Hour the Spirit is loſt, and the Mineral hangs firſt on the Sides of the

the Glaſs, and then falls gradually to the Bottom. It won't keep quite ſo well as the *Spaw* or *Tunbridge* Water. Its Taſte is maſculine and auſtere; the Smell ferruginous and ſtrong, ſomething upon the Sulphur: People ſay it ſmells like Gun-powder. It will make the Root of the Tongue of the Drinkers look blackiſh. Linnen waſh'd in it turns yellow. It will not lather with Soap. The Glaſſes the Water is dipp'd with grow yellow, which no Scowering can take off, and are apt to fly. In froſty and cold Weather it is ſo warm as to melt Ice and Snow; in other Seaſons 'tis cold; tho' not ſo cold as ſome Spring Waters are.

The Weight of this Water varies much according to the Seaſons of the Weather. In *May* 1704, it weigh'd three Grains lighter than common Water in the Quantity of a Pound. In the Spring of 1705, it was equal in Weight to common Water; and is now ſtill heavier in *Auguſt* following, becauſe of the exceeding dry Weather of that Summer. But in general about *Midſummer*, if the Weather is no ways extraordinary, it's pretty equal to common Water in Weight.

A ſingle Grain Weight of good Gall will turn a Pint and a half of this Water of a very noble deep Red, and in an Inſtant. Syrup of Violets turns it of a Graſs green. With the Infuſion of *Braſile*, it giveth a deep lively Blue: With that of *Lign. neph.* firſt a light Green, then a light Yellow, with a blue Crown: With the Infuſion of Logwood, a blue Black: With that of Fuſtick Wood, a duſky Yellow: With the Flowers of Pomgranates, a fair Violet: With the Leaves of Tea, a fine purpliſh Blue: With good *Nantz* Brandy, an elegant Sky-colour. It turns a Solution of the *Sacch. Saturni* milky in an Inſtant; and the Solution of *Sublimate* in ſome Time longer. *Ol. Tart. per deliq. Sp. Sal. Armon. Sp. Vitr. &c.* make no ſenſible Alteration.

In calm Weather, in Winter eſpecially, a thick oily Film covers the Surface of theſe Waters, of as great a Variety of Colours as a Rain-bow; a Spoonful of it drunk, hath the Effect of, and compoſes as much to Sleep as, a moderate Doſe of Opium. Some of this Scum, being dry'd by Evaporation, taſted very fat, and felt ſo between the Fingers. Some of this Powder being caſt upon a red hot Iron, moſt of it immediately burn'd away with ſparkling; and what remain'd was of the Colour of Ruſt of Iron, and taſted partly Stiptic and Earthy, and partly Saltiſh.

The Water itſelf, being gently evaporated, yields a yellowiſh Sediment, more or leſs, according to the Seaſons. Laſt Spring a Quart yielded ſix Grains of it; but in *September* following, the ſame Quantity afforded me nine Grains; whereas a Pound of *Tunbridge* Water gave but one ſingle Grain of Sediment to Mr. *Boyle*, as appears by his *Memoirs of Mineral Waters*. This Sediment, being boil'd in com-

mon Water, made a ſtrong *Lixivium*, with which Acids caus'd no ſenſible Fermentation; but Syrup of Violets turn'd it Green. This *Lixivium* being evaporated, yielded a fat Sulphurous Salt, that would not coagulate into Cryſtals. I can get but three or four Grains of it out of ten Grains of Sediment; but from the Colour and Taſte of the *Lixivium*, I have Reaſon to ſuſpect, that there is a larger Proportion of Saline Particles, which, as I conceive, being Volatile, evaporate away with the Water.

As for its Medicinal Virtues, from the many and truly wonderful Cures, I believe it to be one of the moſt excellent Waters of this Kind, as yet found out in *England*. The little Well is very uſeful in Diſeaſes of the Breaſt, as in Aſthma's, Coughs, Rheums and Catarrhs. It hath cur'd ſeveral given over of Conſumptions of the Lungs. Moſt Diſorders of the Stomach are cur'd by this Water. It ſeldom fails in the Cure of Rheumatick Gouty Pains of the Limbs, or other Parts of the Body, in the Scurvy and Melancholy Diſtempers, Jaundice, Vapours, all ſorts of Stoppages, Scabs, Itch, *&c.* But in Gravel, Cholick, and Green-ſickneſs, 'tis a true Specifick; as alſo in inward Ulcers, if not too far gone. A Porter of *Bolton*, who had been with many Doctors, and was laſt Spring diſcharg'd out of St. *Thomas*'s Hoſpital, as an incurable Perſon, hath been cur'd of his Ulcer in the Bladder this Summer, with drinking of this Water for three Months together.

In Agues it is beyond the Bark: I have ſeen ſome Rebellious ones, that could not be remov'd by the Bark, perfectly cur'd by this Water, and ſome Conſtitutions quite worn out by the frequent Relapſes of this Diſtemper, reſtor'd again. This is alſo remarkable, that it agrees beſt with old, decay'd, and weak Conſtitutions. The Water ſits pleaſantly upon the Stomach, works off by Urine very briſkly, cauſeth a good Appetite, clears the Spirits, and procures Sleep. It is not binding, as ſome other Chalybeats are, but keeps the Body open to moſt People, and upon ſome it brings now and then a gentle Looſeneſs, which carries off the Diſtemper. For theſe four Years I have preſcrib'd them to many Scores of People every Seaſon, and I could never obſerve any Inconveniency, or ill Symptom ariſe from the Drinking of them.

An Examen *of the* Spaw Waters, *proving them to be* Alcalies, *by Dr.* F. Slare. n. 337. p. 247.

VIII. I have long ſince been of Opinion, that People have been miſtaken in their Notions about the Nature and Properties of thoſe Mineral Waters, which are of the *Chalybeat* or Iron Species. *Germany* abounds much with theſe Waters, and they beſtow one general Name upon them, and call them *Sour Brunns*, that is, *Sour* Wells, or Springs of Water. *Henricus ab Heers* agrees with *Vitruvius*, *Fallopius* and *Helmont*, in juſtifying the Acidity of ſeveral ſorts of *Spaw* and *Chalybeat* Waters; but, not being ſatisfied with their Reaſons, aſſigns

aſſigns others; and after a tedious Harangue, concludes, that they owe their Birth and great Virtues to Vitriol and Sulphur. He obſerves, that Vitriol and Sulphur are found in the Glebe or Earth from whence theſe Waters ſpring; but yet does not give us one Proof or Experiment of his having found any real Vitriol, or true Sulphur, or any Acidity in theſe Waters.

Dr. *Jordis*, who practiſed Phyſick at *Francford*, and often at *Swalbac* in Summer Time, at my Deſire, examin'd thoſe Waters. He gave me an Account of ſome *Ocres*, or Ferruginous Parts, which he calcin'd and tortur'd in the Fire, to make them confeſs their Sulphur Original; but in all his Experiments did not ſatisfy me, that the Water held one Drop of an Acid by Diſtillation, *&c.*

That which gave me the firſt Suſpicion, that the *Chalybeat* Waters did not contain any rough, or vitriolic, or acid Salts in them, proceeded from an accidental Uſe of a ſtrong Iron Water, in which I diſſolv'd Soap, and found it lather and waſh my Hands well, and then I us'd a Waſhball and ſhav'd with it, and try'd ſeveral other Waters of this ſort, which did the ſame, and much better than ſome Pump-Waters.

I conſulted my Palate, and try'd whether I could diſcover any Sharpneſs or Acidity in our *Engliſh* Steel-Waters at *Tunbridge*, at *Black-Boy* in the Pariſh of *Franfield* in *Suſſex*, *Hampſted*, *Sunning-Hill* in *Berkſhire*, &c. but I was ſo far from diſcovering any ſuch Thing, that theſe Waters ſeem'd rather to leave a ſweetiſh Flavour behind: Thus many Alkali Salts, if nicely examin'd (of the fix'd kind) have affected my Taſte.

I made Experiments with ſeveral Sorts of ſuch Spirits as are apt to ferment with Acids; ſuch as Spirit of *Hartſhorn*, of *Sal Armoniac*, &c. but theſe made no Ferment, nor any Motion or Change in theſe Waters.

I conſider'd the Diſeaſes in Human Bodies, which theſe Waters were preſcrib'd, by Phyſicians, to cure; that they were often ſuch as proceeded from ſharp, acid, or acrimonious Cauſes, as *Cardilage*, or Heart-burnings, ſour Vomitings, corroſive *Diarrhœa*'s, Cholicks, from Scurvies and Stranguries; and that for theſe Diſtempers ſweetning and alkaliſate Remedies are made uſe of.

I conſider theſe Waters as containing in them the Properties of Iron; and I find by Experience, that it is moſt oppoſite to Acids, being one of their great Correctors, and therefore rather to be eſteem'd an Alkali.

Take ſome Filings of Iron, perhaps a Dram, and pour on them about an Ounce of the milder Acids, ſuch as Vinegar, Verjuice, or the Juice of Lemons, and it will deſtroy the Sharpneſs of theſe Juices: Or if you pour on theſe Filings Mineral Acids, as the very corroſive Spirit of Nitre, or of Salt, or what is call'd Oil of Vitriol, they will immediately loſe their Acidity, be diſarm'd of

their ſharp Points, and by Evaporation give a Salt that will taſte ſweetiſh, and is by Chymiſts call'd *Saccharum Martis*, if duly prepar'd; which is ſafely given inwardly, and is eſteem'd a good altering Medicine.

Steel beaten to a fine Powder, is, without any farther Preparation, given inwardly with great Succeſs for Stomachic Diſeaſes, as in the Green Sickneſs, Hypochondriac, and various other Acid and Acrimonious Diſaffections.

I conſider'd Milk to be a very proper and obvious Subject to bring this Controverſy to a plain and unqueſtionable Deciſion. I made this Experiment with all poſſible Exactneſs: I firſt prov'd the *Chalybeat* Waters, more particularly the *Spaw* Waters, by trying whether they tinged with Galls. Theſe being very good, I put part of the Waters to cold Milk; ſome I only made lukewarm, and ſome I boil'd together, in equal Proportions: But they were ſo far from affording any Curd or Coagulation, that they continu'd ſeveral Days without being ſour.

The *German* Phyſicians (on the miſtaken Notion of their being Acid) ſtrictly prohibit their Patients the Uſe of all manner of *Lacticinia*, whilſt they are in a Courſe of theſe Waters.

This Prejudice too, has prevail'd much amongſt moſt of our Water Drinkers in *England*; but I do atteſt, that I have frequently advis'd, in ſome Caſes, Milk to be given daily in the Evening, through a whole Courſe of Steel Waters, with good Effect: Nay, I do affirm, that ſome others could not bear the Waters without having a third Part of Milk, or more, mix'd with them, and have continu'd them ſo for many Weeks, with good Advantage: Nor do I find the leaſt Reaſon to prohibit the Uſe of Milk in a Courſe of *Bath* Waters; having been there above a Year and half, making the beſt Scrutiny I can into the Properties, Virtues, and Vices (if they have any) of thoſe Waters.

Since our Experiments diſcover that thoſe Things which are of a ſweetning *Alkaliſate* Nature, do ſo very well agree with theſe Mineral Waters, it will appear by the following Experiment, that Acids do very much diſagree.

I put but one Drop of Oil of Vitriol to a large Glaſs full of ſtrong *Spaw* Waters, which before the Addition of this *Acid* did give a deep Purple to the Solution of Galls; but now would not give the leaſt Tincture, though I put in four Times as much of the Galls. From hence I conclude, that the Virtues of the *Chalybeat* Ingredients, which I take to be the Life and Soul of theſe Waters, were ſo far bound up or deſtroy'd, as to have loſt their Cordial or corroborating Faculty; and that the Bile or Gall in the Human Bowels, could not be able to ſeparate the *Chalybeat* (which are the only Medical) Particles, and mix them with the Chyle, in order to anſwer any End in Phyſic.

Let

Let this be a Caution to thoſe that deſign to make theſe Waters paſs better by Urine, that they do not make uſe of any *Acids*; it being a common Practice to uſe Spirit of Vitriol, *Spiritus Nitri dulcis*, &c. as a Diuretick: Unleſs it ſhould ſo happen that they have a Deſign to take off, and diveſt them of their warm Cordial or altering Power, and ſo to bring them near to common Water; which, I muſt confeſs, we are forc'd to do, eſpecially in the Uſe of *Bath* Waters, in ſome hot inflammatory Caſes.

I ſhall conclude with one ſhort Experiment in Favour of our *Alkali's*; that if you put any *Alkali* Salt, volatile or fix'd, ſuch as Volatile Salt of Hartſhorn, or of *Sal Armoniac*, or fix'd Salt of *Tartar*, of Wormwood, or any other true *Alkali*, you will then deſtroy the above-nam'd Acid Spirit, recover the Virtue of the Waters, and diſpoſe them to give their Tincture as they uſed to do in their natural State.

Of the Nature *and* Virtues *of the* Pyrmont *Waters, by Dr.* F. Slare. n. 351. p. 564.

IX. Having procur'd about a Dozen Quarts of *Pyrmont* Waters this laſt Summer, I made ſome Trials with them. I found by the Taſte, that they contain'd a rich *Chalybeat* Virtue, and alſo made a very briſk and lively Impreſſion on the Palate, more grateful and ſpirituous, than the beſt *Spaw* Waters I ever taſted. The *Spaw* Waters are look'd upon as moſt excellent, if they ſparkle a little in a Glaſs; but theſe, in Summer-time, when pour'd into the Glaſs, nay, ſometimes even in the Bottle, as ſoon as the Cork was open'd, and the Air was admitted, would make a notable Ebullition, ſomewhat like bottled Cyder, though this was ſoon over; but they did yet continue their ſmart and briſk Taſte, and highly *Chalybeat* Reliſh, to the laſt Drop, though we were ſome Hours in drinking them off. In the Winter-time, theſe Waters do not ſparkle, nor ferment, at leaſt mine did not; but they were not carefully preſerv'd, being expos'd in cold Cellars; and yet, notwithſtanding, they loſt not the *Chalybeat* Taſte, and alſo retain'd a very pleaſant briſk Guſt. Theſe Waters have been reckon'd in the Number of the *German Acidulæ*, and ſome of my Friends, to whom I gave a Glaſs of the Water, have aſcrib'd to it a ſharp Taſte, and have been ready to run away with a poſſeſs'd Opinion of its being ſour: But, when I have deſir'd them to conſider, they have own'd that the ſmart and briſk Taſte miſled them to call it Acid or truly ſour: Thus Cyder and ſoft Ale, when bottled, will give ſuch an acute Affection to the Palate, when it is far from being ſour: And even *Volatile Alkalies* of *Sal Armoniac*, or of Hartſhorn, may be made to give the like Pungency to the Tongue.

In order to a more nice Enquiry, whether any Acidity were diſcoverable in theſe *Pyrmont* Waters, we dropp'd in conſiderable Quantities both of Spirit of Hartſhorn, and of Spirit of *Sal Armoniac*, both

both juſtly prepar'd; but could not diſcover the leaſt Luctation or Motion to appear upon this Conjunction, as it uſually does with an Acid.

I made a yet more nice and certain Examen of theſe Waters, by mixing Milk with them, ſometimes in equal, ſometimes in double Proportion; and in various Degrees of Warmth, both in lukewarm Degrees, and alſo with a boiling Heat, but I could not perceive any Curdling. But rather, on the contrary, the Water preſerv'd the Milk from Coagulation, for four or five Days, even in *September*, it being hot Weather.

Take a very little Gall in Powder, about half a Grain to a Glaſs of a Quarter of a Pint; this does in a Moment render it turbid, and make a dark Purple, eſpecially if you ſtir it: But if you drop the Powder on the Surface of the ſame Water, it then cauſes a fine blue Tincture. If you will make a very fine Tincture pleaſant to the Eye, take five Leaves of ſtrong Green Tea, put them into the Bottom of a Glaſs holding a Quarter of a Pint, and you will ſee thoſe Leaves unfold themſelves, and in a Quarter of an Hour, tinge the Water with ſuch a ceruleous Azure Blue, that few Vegetables do afford the like. We obſerve, that the longer theſe Leaves, or any other Stiptics, (which are the Precipitators) do ſtay together, the more they degenerate into a deep Purple, or even to an Atramentarious Colour.

In reference to the internal Uſe of theſe Waters, I drank about a Quart at a Time, after this Manner: I firſt began with the *Spaw* Waters, which I procur'd very good, and drank them for a Week, and they agreed very well. I then drank the *Pyrmont* Waters for three or four Days, and continu'd the Uſe of theſe Waters alternately, until I had drank about twenty Days. By the Reſult of my Experiment, it ſeem'd to me very plain, that the *Pyrmont* Water was more agreeable, gave more Strength and Spirit, and was as much or more preferable for its internal Virtue, as for its excelling the other in a briſker and more ſprightly Taſte.

There is another Excellency in theſe Waters, which will make them more uſeful to us, than any foreign *Chalybeat* Waters we yet know, becauſe theſe will keep better; they are not ſo ſoon ſpoil'd by any accidental Inſinuations of Air, as the *Spaw* are ſubject to be. The *Chalybeat* Mineral is here throughly diſſolv'd and well united, and mix'd in this Water, ſo that it does not eaſily precipitate: For which Reaſon, it may alſo the better paſs the *vaſa lactea*, and even enter into the Maſs of Blood it ſelf, and work the more conſiderable Effects. That this is not a bare Hypotheſis, may be prov'd by this Experiment.

Having ſuffer'd the *Spaw* Water to be expoſed in a Bottle which was half full, and unſtopp'd twelve Hours, I examin'd it, and found

found it taſte juſt like common Water; but the *Pyrmont* Waters that were open'd to the Air after the ſame Manner, taſted ſtrong of the Mineral, and gave their Tincture as at firſt; nay, they continu'd thus for full two Days, and perhaps might have done ſo longer, but I thought that Time ſuffic'd.

An Additional Account. Ibid.

Having had lately ſome Diſcourſe about a *Purging* Quality contain'd in theſe Waters, I am now inquiring whether they in Reality do contain any purging Ingredients or Properties.

I evaporated about a Quart of this Water *ad ſiccitatem*; I then poured on the *Reliquiæ* ſome Rain-Water, enough to diſſolve and take up the Salts, and exhal'd that Water, and had a Grain or two of the Salts, that taſted *Muriatic*, ſuch as moſt River and Pump Waters give. It is well known that the Purging Waters have a very bitter Taſte, and by Dr. *Grew*, that Salt was call'd *Sal Cathartícum amarum*, which diſtinguiſh'd it from all other Species of natural Salts: That of the *Pyrmont* Water abovementioned has no Relation to this, but to the Sea Salt, not being in the leaſt bitter.

It is alſo well known, that unleſs our Waters be impregnated with a conſiderable Quantity of this bitter Salt, it will not purge at all: Two or three Grains ſignify nothing, nor have the leaſt Cathartic Power. For Example, put two Drachms of the purging Salts to a Quart of common Water; and this Quantity will give but a Stool or two to one who is naturally very eaſy to work upon. I have examin'd ſeveral other *Chalybeat* Waters, and found much the like Ingredients, and never any that I could ſuſpect to carry any purging Properties.

I think we can much better demonſtrate that the *Chalybeat* Waters do contain Stiptic and Reſtringent Virtues, becauſe they owe their Birth to the *Iron Mineral*, and more particularly to the *Pyrites*, which Dr. *Liſter* ſuggeſts, (not without ſome Reaſon) to be the Parent even of all *Iron Oars*, as it is doubtleſs the Cauſe of all *Chalybeat* Waters: Thus I have often examin'd the Solution of the *Pyrites* by the Rain-Water at *Deptford*, and at other Places, where *Copperas* is made, and found it a very ſtrong *Chalybeat* Water. It is from this *Mineral* we have our ſtrong Stiptic and conſtringent Medicines, for external and internal Uſe; we have our Powders and Salts of *Steel*, or *Vitriol* of *Mars*, from hence; nay, even obſtinate and inveterate *Diarrhœas* have, by a judicious Uſe of *Tunbridge* and other Iron Waters receiv'd a Cure.

But it is aſſerted that the Waters really do purge at *Pyrmont*, where they are drank.

This we do allow to be true, that *Tunbridge* Waters do not only purge, but ſometimes vomit, when drank haſtily and in great Quantity, but our Phyſicians have corrected this Irregularity, and we hear of no ſuch Complaints, where they obſerve a juſt *Regimen*: And

And we do all agree, that thoſe Waters are, in their own Nature, binding, and do oft require ſome opening Medicine. The Quantities of Water drank at *Pyrmont* are very large, often two or three *Engliſh* Quarts. It is no Wonder that their Weight forces them through the Bowels; for any common Water, drank haſtily, and in ſuch Quantity, will do the ſame. Whereas, if you take this Method, and will drink *Pyrmont*, or any other *Chalybeat* Waters leiſurely, *viz.* a Pint-Glaſs in an Hour, or rather two Half-Pint Glaſſes, you may drink three Pints in ſo many Hours without Danger of loſing them by Dejection. But if any one will be careful, and take this Caution with him, he will ſcarce fail of Succeſs; that is, let him be very quiet and ſtill, both in Body and Mind; the leſs he ſtirs or walks, the better he will paſs off his Waters by Urine.

I ſhall mention only one Obſervation more, which is, that none of our *Engliſh* Steel Waters do ſtrike ſuch a Purple as the foreign celebrated *Chalybeat* Waters do; for ours do give a more turbid and dark Colour, and the worſe the Waters are, the blacker Sediment they make: Thoſe of *Iſlington* abound with a coarſe *Oker*, the Mineral is not well diſſolv'd, but gives an *atramentarious* Colour; but the *Pyrmont* Waters excel all I have happen'd to examine, in its bright *Cæruleous* Luſtre.

N. B. *Moſt of the Experiments alledg'd by Dr.* Slare, *in the foregoing Diſcourſe, were likewiſe by him ſhewn before the* Royal Society, Feb. 28. 1717, *and it was found that the* Pyrmont *Waters gave a much brighter Tincture with Galls and Tea, and had a much more exalted* Chalybeat *Taſte than the* Spaw; *and a ſmall Quantity of each being kept for ſome Time in Bottles, to compare them, the* Pyrmont *was found to have retain'd its Virtues much better than the* Spaw. *The Preſident, and ſeveral of the Members preſent, having drunk a Glaſs of it, found it of a very agreeable Reliſh, and to ſit eaſy on the Stomach.*

X. *Accounts of Books Omitted.*

n. 276. p. 1038. 1. *Aloyſii Ferdinandi* Comit. *Marſigli Danubialis Operis Prodromus,* Ad Regiam Societatem *Anglicanam.* Folio 1700.

n. 308. p. 2346.] 2. Dr. *Ehm*'s Treatiſe of St. *George*'s Bath by *Landeck*, in the Lordſhip of *Glats* near *Sileſia.*

CHAP.

CHAP. III.

Mineralogy.

I. MArmor debet eſſe politum ſine omni macula; durum, ut Ignis vim eo melius ſuſtineat, ideo Alabaſtrum his uſibus minime Idoneum. *The Way of* Colouring Marble, *by* —— n. 263. p. 735.

2. Ad aperiendos poros igne opus eſt, tali tamen gradu ne Igniatur; nam tum colores Comburuntur; nec nimis tepido, nam etſi tum Colores recipiat, recepti tamen minus figuntur: nam marmor etiam frigidum imbibet aliquot colores ſc. Crocum *Stone blue* pro Colore cæruleo, verum hi colores facillime per minimum calorem igne diſſipantur: ideo is ignis ſit Gradus qui ſufficiat liquori marmori infuſo leniter ebulliendo.

3. Menſtrua varia ſunt, pro diverſitate materiæ diſſolvendæ, Lixivium ex Urina equina factum cum cineribus clavellatis, part. 4. & calcis viv. part. 1. (N. B. Urina Canina præſtat equinæ) Item Spiritus Vini, Lixivium Commune, Vinum & quædam Oleaginoſa.

4. Colores qui cum vehiculis inducuntur hi ſunt. 1. *Stone blue*, in ſpirit. vin. vel lixivio calcis viv. ſolut. 2. Lackmus in lixivio vulgari. 3. Crocus vel *Sapgreen* ſolutum cum lixivio ex Urina & Calc. viv. vel in Sp. Vini. 4. Vermilion vel Cochineel diſſolut. ut ſupra. 5. Sang. Draconis in Sp. Vini S. Art. ſolut. 6. Braſilium lignum in Sp. Vini ſolut. 7. Radix Alcannæ cum oleo Terebinth. Extract. nam in nullo alio menſtruo nec Spiritu vini nec in lixivio ſolvitur. 8. *Sapgreen the leſs* mixt. & diſſolut. in Sp. Vini vel lixivio calc. viv. ut antea. Aliud Genus Sanguinis Draconis eſt, quod vocatur Lachrima Sanguinis Draconis, quod cum Urinis mixtum gratum ſatis producit colorem, verum ægre acquiretur, melius Colores cum Urina mixti finem non eludunt.

5. Colores qui ſine vehiculo illinuntur hi ſunt. 1. Sang. Draconis optime mundat. ad Colorem rubrum. 2. Gumm. Gutt. ad Col. flav. 3. Cera virid. ad color. virid. 4. Sulphur, pix, Terebinth. ad Colorem brunum requiritur tantummodo ut Marmor rite ferveſcat, & ita Colores grumatici fricando inducuntur, quod experientia docebit.

Hi Colores vel facile vel difficulter eluuntur, ruber Color cum oleo Tartari per deliquium intra 26 horas extrahitur ſine ulla polituræ jactura; Brunus cum aqua forti intra quartam horæ partem, ſed læſa politura.

Pro Colore Aureo ſic fac; R. ſalis armoniaci, Vitrioli albi, flor. virid. æris; pulveriſentur ſubtiliſſime.

Of a Quarry of Marble *in* Ireland, *by Mr.* F. Nevile. n. 337. p. 278.

II. I was lately with Mr. *Cole* in the Mountains in the County of *Farmanagh* in *Ireland*, where I had diſcover'd a Marble Quarry. The Countrey wherein it lies, is ſo ſtrange for the natural Wonders in it, that it would make a little Hiſtory to deſcribe all that is to be ſeen: It lies on the North-ſide of *Calcagh*, in the Pariſh of *Kilaſher*, in the County of *Farmanagh*. There are Marble-Rocks, whoſe perpendicular Height is 50 or 60 Feet, diſcover'd by Subterraneous Rivers, which by Degrees have waſh'd away the Earth and looſe Stones, and diſcover'd theſe mighty Rocks. There are many great Pits fallen in on the Sides of the great Mountain; ſeveral of them in a ſmall Compaſs of Ground, ſo that it is dangerous Travelling near them. There are many Caves form'd, ſome very large, the Sides and Arches of Marble, ſome of a Liver-Colour, varied in white with many little Figures; ſome of a light Blue varied with white; but I could find no entire black and white amongſt them.

An Account of a Colliery blown up; *by* —— *Communicated by Dr.* A. Charlett. n. 318. p. 215.

III. On the 18*th* of *Auguſt* 1708, at *Fatfield*, in the Pariſh of *Cheſter Le Street*, about Three of the Clock in the Morning, by the ſudden Eruption of a violent Fire, which diſcharged itſelf at the Mouths of three Pits, with as great a Noiſe as the firing of Cannon, or the loudeſt Claps of Thunder, threeſcore and nine Perſons were deſtroyed in one Inſtant. Three of them, *viz.* two Men and a Woman, were blown quite up from the Bottom of the Shaft, fifty ſeven Fathom deep, into the Air, at a conſiderable Diſtance from the Mouth of the Pit: One of the Men with his Head almoſt off, and the Woman with her Bowels hanging about her Heels.

The Engine, by which the Coals were drawn up, and is of a great Weight, was removed and caſt aſide by the Force of the Blaſt; and what is more wonderful, the Fiſh which were in the Rivulet, that runs twenty Yards under the Level, and at as great a Diſtance from the Mouth of one of the Pits, were in great Numbers taken up dead, floating upon the Water: Whether this happen'd by the violent Concuſſion of the Air, or whether they were choaked with the Sulphur, that to be ſure in Abundance diſperſed itſelf abroad, I leave to others to determine; only this I obſerve, that for ſeveral Days a very ſtrong and noiſome Smell continued to come out of the Pits.

As to the Cauſe of it, it is to be premiſed, that Coal Mines are in general ſubject to *Stith* or *Sulphur*.

Stith, as vulgarly ſo called by the Pitmen, I think corruptly, from Stench or Stink, is a Want of Air, or rather ſuch a Foulneſs in the Air, that overcomes the Spirits of the Men, and ſo ſuffocates them, as well as extinguiſhes the Candles.

Sulphur differs in this, that as the other ſuffers not the Candles to burn, this makes them burn too faſt; and the Flame by the impulſive Quality of the Air, or attracted by the Sulphur, extends itſelf upwards

wards into a prodigious Length, and as a Match lighted for the Diſcharge of a Cannon, as ſpeedily ſets on Fire that Vapour, equally deſtructive.

Now to prevent both theſe Inconveniences, the Viewer of the Works takes the beſt Care he can to preſerve a free Communication of Air through all the Works; that as the Air goes down one Pit, it ſhould aſcend another; but it happen'd in this Colliery, that there was a Pit which ſtood in an Eddy, where the Air had not always a free Paſſage, and which in hot and ſultry Weather was very much ſubject to Sulphur: And it being then the Middle of *Auguſt*, and ſome Danger apprehended from the Cloſeneſs and Heat of the Seaſon, the Men were withdrawn from their Work in that Pit, and turned into another; but an Overman, ſome Days after this Change, and upon ſome Notion of his own, being induced, as is ſuppoſed, by a freſh, cool, froſty Breeze of Wind, which blew that Morning, and which always clears the Works of all Sulphur, had gone too near this Pit, and had met the Sulphur juſt as it was purging and diſperſing it ſelf; upon which the Sulphur immediately took Fire by his Candle, and ſo he proved the Occaſion of the Loſs of himſelf and ſo many Men, and of the greateſt Fire that ever was known in theſe Parts.

An Account of the Eruption *of Mount* Veſuvius *in* 1707. *by the Honourable* J. Valetta. n. 337. p. 22.

IV. 1. Montis *Veſuvii* adeo frequentes contingunt Eruptiones, ut pene innumeræ ſint, nec menſis unus ne dicam Annus prætereat, quo aliquo Motu vel modo minori, modo majori excidio non ſæviat. Anno autem 1707 ingens ſane Incendium contigit, in quo multa, quæ non in aliis aut prioribus aut ſequentibus, obſervata.

Anno 1707, cum jam Æſtas ingraveſceret, in extremis menſis Julii diebus *Veſuvianus* mons, qui diu quieverat, aliqua motus ſigna edere incepit, nam interni mugitus primo auditi ſunt, qui in ipſo montis umbilico perſonabant, nullo tamen adhuc dato aut fumi aut flammæ indicio. Deinde paulatim poſt editos ſonitus fumum emittere & clarum ignem incepit, qui noctu præſertim toti *Campaniæ* illuceſcebat. Per varia interim intervalla bombos dedit adeo horriſonos, ut vix ipſis comparandi ſint crepitus e majoribus noſtri temporis tormentis bellicis eliciti: Inde cineres veluti ex materia jam pinſata interius volvere perſeveravit, per plures dies nocteſque eos undequaque volvens in cœlum elatos, & in varias regiones diſperſos, ſicuti ventus ſpirabat diverſus, modo in ſubjecta maria, modo in *Stabianos*, modo in *Nolanos*, & *Acerranos* agros eos ejiciens. Nec ſilentio prætereunda vehemens lapidum pluvia, quæ cum omnibus, tum jumentis exitio fuit. Poſt hæc liquidum bituminis flumen, quod glaream vocant, e patulo ore, uti alias, vomere incepit, quod ignitam primo torrentis placidi formam habebat, ea motus lenta celeritate ſe deorſum moventem, quam in pice liquefacta aut denſioribus aliis obſervamus. Hæc materies, quam vitro ex arena liquefacto compararem in ferventiſſimis fornacibus, item ac vitrum ubi procedens deferbuerat, lapideam duritiem acquirebat. Illud autem obſervatu

ſervatu dignum quod ſuperior hujus materiei deferveſcentis ſuperficies in lapides minutos ſpongioſos ſe vertebat ; inferior verò in ſolidum latiſſimum & duriſſimum ſilicem, quo in ſternendis viis ab antiquo utimur ; quaſi quæ proxima aeri erat, illius particulas retineret immiſtas, inferiore parte, nullo inani admiſto, in compactiſſimam maſſam coacta. Cæterùm inter plurima montis efferveſcentis Phænomena, duo certè fuere a multa ætate non viſa, & ignota : Tertio namque die aut quarto, fulgetra emittere ex orificio cepit, ejuſdem ferè aſpectus, ac quæ e Cœlo interdum micare videmus, ſed tortuoſa & ſerpentia, & in eorum emiſſione tonitruorum bombi audiebantur, ut Cœlo tonante eadem timemus: Fuere ea tam ſpiſſa & frequentia, ut primo quidem putaremus pluviam caſuram, uſquequò animadverſum eſt ea ex monte prodire, & obſcuras nubes non ex vaporum materia, ſed denſitate cineris cadentis compactas. Interea IV. Nonas Auguſti, quarta poſt meridiem hora, tanta ingruerat cineris denſitas aerem *Neapoli* imminentem, ut excluſis radiis ſolaribus tenebræ undique ſint inductæ, & quidem ea obſcuritate, ut commeantes per urbem in ipſis compitis ſocios amicoſq; agnoſcere non potuerimus. Nulla nox illo die nigrior ; accenſis facibus ſi quis domo prodierat, redire cogebatur, quod ſolum temporibus *Titi* accidiſſe ex *Xiphilino* accepimus. Magiſtratus urbis & Antiſtes indixerant populo ſupplicationes, & ut longo ordine ad *Capuanam* portam, quæ montem reſpicit, orantes ferrent Divi *Januarii* urbis Tutelaris Sacra λείψανα. Huc ubi ſe contulerant, inter denſiſſimas diei tenebras, tandem circa primam aut alteram noctis horam, ex Septentrionali parte, quam minor fortaſſe occuparat cinerum vis, unum aut alterum ſidus micare viſum eſt, & cærulea facies Cœli apparere, & inde ſenſim per noctem tenebræ minui viſæ ſunt, quæ diem prius oculis abſtulerant. Tum ea Cinerum materies averſo Vento e Noſtra Regione ad Mare ſubjectum perlata eſt. Dies ortus non jam adeo illuſtris, ſed reliquiis etiam cinerum per Aerem interſperſis ſemiclarus, & retinebat——*dubiæ diſcrimina Lucis.*

Sic Arva Cineribus vaſtans Veſuvius, vomitu glareæ per plures dies exhauſtus, ita ut fere ad proximum mare nigerrimus illius torrens profluxerit, tandem poſt quindecim pene dies quieſcere viſus eſt, & circumoppidani qui diffugerant, patriam repetentes ad ſuos Lares migraverunt. *Neapolitani* demum metu levati, ut Divo *Januario*, præſenti iis ſemper in anguſtiis, memoriam perpetuam ſtatuerent, eidem Numiſma cudi curaverunt ex auro Argentoque, ubi Divi *Januarii* Caput cum hac Epigraphe, DIVO JANUARIO LIBERATORI URBIS FUNDATORI QUIETIS ; & altera Numiſmatis facie Pacatus *Veſuvius* cum hac Epigraphe, POSTQUAM COLLAPSI CINERES ET FLAMMA QUIEVIT. CIVES NEAP. INCOLUMES. MDCCVII.

—*of Mount* Veſuvius, *and its* Eruptions *in* 1717. *by Mr.* E. Berkeley. n. 354. p. 708.

2.] *April* 17, 1717, With much Difficulty I reach'd the Top of Mount *Veſuvius*, in which I ſaw a vaſt Aperture full of Smoak, which hinder'd me from ſeeing its Depth and Figure. I heard within that horrid Gulf, certain odd Sounds, which ſeem'd to proceed from the Belly of the Mountain; a ſort of Murmuring, Sighing, Throbbing, Churning, Daſhing (as it were) of Waves, and between whiles a Noiſe like that of Thunder or Canon, which was conſtantly attended with a Clattering, like that of Tiles falling from the Tops of Houſes in the Streets. Sometimes, as the Wind chang'd, the Smoak grew thinner, diſcovering a very ruddy Flame, and the Jaws of the Pan or *Crater*, ſtreak'd with Red, and ſeveral Shades of Yellow. After an Hour's Stay, the Smoak being mov'd by the Wind, gave us ſhort and partial Proſpects of the great Hollow, in the flat Bottom of which, I could diſcern two Furnaces almoſt contiguous; that on the Left ſeeming about 3 Yards in Diameter, glow'd with red Flame, and threw up red-hot Stones with a hideous Noiſe, which, as they fell back, cauſed the before-mention'd Clattering. *May* 8, in the Morning, I aſcended to the Top of *Veſuvius* a ſecond Time, and found a different Face of Things. The Smoak aſcending upright, gave a full Proſpect of the *Crater*, which, as I could judge, is about a Mile in Circumference, and an Hundred Yards deep. A conical Mount had been formed ſince my laſt Viſit, in the Middle of the Bottom. This Mount, I could ſee, was made of the Stones thrown up and fallen back again into the *Crater*. In this new Hill remained the two Mouths or Furnaces already mention'd, that on our Left-hand was in the *Vertex* of the Hill which it had form'd round it, and raged more violently than before, throwing up every three or four Minutes, with a dreadful Bellowing, a vaſt Number of red-hot Stones, ſometimes in Appearance above a Thouſand, and at leaſt three hundred Foot higher than my Head, as I ſtood upon the Brink. But there being little or no Wind, they fell back perpendicularly into the *Crater*, increaſing the conical Hill. The other Mouth to the Right, was lower in the Side of the ſame new-form'd Hill. I cou'd diſcern it to be fill'd with red-hot liquid Matter, like that in the Furnace of a Glaſs-Houſe, which raged and wrought as the Waves of the Sea, cauſing a ſhort abrupt Noiſe, like what may be imagin'd to proceed from a Sea of Quickſilver daſhing among uneven Rocks. This Stuff wou'd ſometimes ſpew over, and run down the convex Side of the conical Hill, and appearing at firſt red-hot, it changed Colour, and harden'd as it cool'd, ſhewing the firſt Rudiments of an Eruption, or, if I may ſo ſay, an Eruption in Miniature. Had the Wind driven in our Faces, we had been in no ſmall Danger of ſtifling by the ſulphureous Smoak, or being knock'd on the Head by Lumps of melted Minerals, which we ſaw had ſometimes fallen on the Brink of the *Crater*, upon thoſe Shots from the Gulf at Bottom. But as the Wind was favourable, I had an Opportunity to ſurvey this odd Scene

for

for above an Hour and a half together; during which, it was very obſervable, that all the Volleys of Smoak, Flame, and burning Stones, came only out of the Hole to our Left, while the liquid Stuff in the other Mouth wrought and overflow'd, as hath been already deſcribed. *June* 5. After a horrid Noiſe, the Mountain was ſeen at *Naples* to ſpew a little out of the *Crater*. The ſame continued the 6*th*. The 7*th*, nothing was obſerv'd till within two Hours of Night; when it began a hideous bellowing, which continued all that Night, and the next Day till Noon, cauſing the Windows, and, as ſome affirm, the very Houſes in *Naples* to ſhake. From that Time it ſpew'd vaſt Quantities of molten Stuff to the South, which ſtream'd down the Side of the Mountain, like a great Pot boiling over. This Evening I returned from a Voyage through *Apulia*, and was ſurprized, paſſing by the North-ſide of the Mountain, to ſee a great Quantity of ruddy Smoak lie along a huge Tract of Sky over the River, of molten Stuff, which was it ſelf out of Sight. The 9*th*, *Veſuvius* raged leſs violently; that Night we ſaw from *Naples* a Column of Fire ſhoot between whiles out of its Summit. The 10*th*, when we thought all would have been over, the Mountain grew very outrageous again, roaring and groaning moſt dreadfully. One cannot form a juſter Idea of this Noiſe, in the moſt violent Fits of it, than by imagining a mix'd Sound made up of the raging of a Tempeſt, the Murmur of a troubled Sea, and the Roaring of Thunder and Artillery, confuſed all together. It was very terrible as we heard it in the further End of *Naples*, at the Diſtance of above twelve Miles. This moved my Curioſity to approach the Mountain. Three or four of us got into a Boat, and were ſet aſhore at *Torre del Greco*, a Town ſituate at the Foot of *Veſuvius* to the South-weſt, whence we rode four or five Miles before we came to the burning River, which was about Midnight. The Roaring of the *Volcano* grew exceeding loud and horrible as we approach'd. I obſerved a Mixture of Colours in the Cloud over the *Crater*, green, yellow, red and blue; there was likewiſe a ruddy diſmal Light in the Air over that Tract of Land where the burning River flow'd; Aſhes continually ſhower'd upon us all the Way from the Sea-Coaſt. All which Circumſtances, ſet off and augmented by the Horror and Silence of the Night, made a Scene the moſt uncommon and aſtoniſhing I ever ſaw; which grew ſtill more extraordinary, as we came nearer the Stream. Imagine a vaſt Torrent of liquid Fire rolling from the Top down the Side of the Mountain, and with irreſiſtible Fury bearing down and conſuming Vines, Olives, Fig-trees, Houſes; in a Word, every Thing that ſtood in its Way. This mighty Flood divided into different Channels, according to the Inequalities of the Mountain. The largeſt Stream ſeemed half a Mile broad, at leaſt, and five Miles long. I walked ſo far before my Companions, up the Mountain, along the Side of the River of Fire, that I was obliged to retire in great Haſte, the ſulphureous Steam

Steam having ſurprized me, and almoſt taken away my Breath. During our Return, which was about Three a Clock in the Morning, we conſtantly heard the Murmur and Groaning of the Mountain, which between whiles would burſt out into louder Peals, throwing up huge Spouts of Fire and burning Stones, which falling down again reſembled the Stars in our Rockets. Sometimes I obſerv'd two, at others three diſtinct Columns of Flame, and ſometimes one vaſt one, that ſeemed to fill the whole *Crater*. Theſe burning Columns, and the fiery Stones ſeemed to be ſhot 1000 Foot perpendicular above the Summit of the *Volcano*. The 11*th* at Night I obſerved it from a Terraſs in *Naples*, to throw up inceſſantly a vaſt Body of Fire, and great Stones to a ſurprizing Height. The 12*th* in the Morning, it darken'd the Sun with Aſhes and Smoak, cauſing a ſort of Eclipſe. Horrid Bellowings this and the foregoing Day were heard at *Naples*, whither Part of the Aſhes alſo reached. At Night I obſerved it throw up Flame, as on the 11*th*. On the 13*th*, the Wind changing, we ſaw a Pillar of black Smoak ſhot upright to a prodigious Height. At Night I obſerved the Mount to caſt up Fire as before, tho' not ſo diſtinctly becauſe of the Smoak. The 14*th*, A thick black Cloud hid the Mountain from *Naples*. The 15*th* in the Morning, the Court and Walls of our Houſe in *Naples* were cover'd with Aſhes. In the Evening, Flame appear'd on the Mountain through the Cloud. The 16*th*, the Smoak was driven by a Weſterly Wind from the Town to the oppoſite Side of the Mountain. The 17*th*, the Smoak appear'd much diminiſh'd, fat and greaſy. The 18*th*, the whole Appearance ended, the Mountain remaining perfectly quiet without any viſible Smoak or Flame. A Gentleman, whoſe Window look'd toward *Veſuvius*, aſſur'd me, that he obſerv'd this Night ſeveral Flaſhes, as it were of Lightning, iſſue out of the Mouth of the *Volcano*. I ſhall not mention the Conjectures I have formed concerning the Cauſe of theſe *Phænomena*, from what I obſerved in the *Lacus Amſancti*, the *Solfatara*, *&c.* as well as in Mount *Veſuvius*. But this I may ſay, that I ſaw the fluid Matter riſe out of the Center of the Bottom of the *Crater*, out of the very Middle of the Mountain, contrary to what *Borelli* imagines, whoſe Method of Explaining the Eruption of a *Volcano* by an inflexed Siphon, and the Rules of *Hydroſtatics*, is likewiſe inconſiſtent with the Torrent's flowing down from the very *Vertex* of the Mountain.

V. On the 28*th* of *December* 1703, there happen'd an Earthquake in theſe Parts. From *Hull* I am informed, that it was felt about three or four Minutes after five in the Evening; that it heav'd up Chairs and Tables, made Pewter-Diſhes and the Windows rattle, ſhook whole Houſes, and threw down Part of a Chimney. The Shock came and went ſuddenly, and was attended with a Noiſe like the Wind, though there was then a perfect Calm. *An Account of an* Earthquake *in the* North *of* England, 1703. *by Mr.* R. Thoreſby. n. 289. p. 1555.

It was felt in much the ſame Manner at *Beverly* and other Places, and particularly at *South-Dalton*. It was more violent near *Lincoln*, where it heav'd up the Chairs; and, as a certain Clergyman informed me, ſhook every Limb of him. At *Selby* it was felt pretty much; as alſo near *Navenby*, where the Noiſe which preceded it ſeemed to ſome like the Rumbling of two or three Coaches driven furiouſly, and immediately the Chairs they ſat on were ſhook violently, and the very Stones were ſeen to move.

Of Trees *found under* Ground *in* Hatfield-Chace, *by Mr.* Abr. de la Pryme. n. 275. p. 980.

VI. 1.] The Levels of *Hatfield-Chace* in *Yorkſhire*, were the greateſt Chace of red Deer that King *Charles* the Firſt had in all *England*; containing in all Limits above 180000 Acres, about half of which was yearly drowned and ſurrounded with an Ocean of Waters. This he bargains with, and ſells to one Sir *Cornelius Vermuiden* a *Dutchman*, to diſchace, drain, and reduce to Arable and Paſture Land; which to the Surprize of all, and to the great Advantage of the Countrey round it, he at length effectually perform'd at the Expence of above 400000 Pounds.

In the Soil of all, or moſt of theſe 180000 Acres of Land (of which 90000 were drained) even in the Bottom of the River of *Ouſe*, in the Bottom of the adventitious Soil of all *Marſhland*, and round about by the Skirts of the *Lincolnſhire* Woolds unto *Gainſburg*, *Bautry*, *Doncaſter*, *Baln*, *Snaith*, and *Holden*, are found infinite Millions of the Roots and Bodies of Trees, great and little, of moſt of the Sorts, that this Iſland either formerly did, or at preſent does produce, as Firs, Oaks, Birch, Beech, Yew, Wirethorn, Willow, Aſh, *&c.* the Roots of all, or moſt of which ſtand in the Soil in their natural Poſtures, as thick as ever they could grow, as the Bodies of moſt of them lie by their proper Roots. Moſt of the great Trees, by all their Length about a Yard from their great Roots (unto which they did moſt evidently belong, both by their Situation and the Sameneſs of the Wood) with their Tops commonly North-Eaſt, though the ſmaller Trees lie almoſt every Way croſs thoſe, ſome above, ſome under, a third Part of all which are Firs, ſome of which have been found of thirty Yards length and above, and have been ſold to make Maſts and Keels for Ships. Oaks have been found of 20, 30 and 35 Yards long, yet wanting many Yards at the ſmall End. Some of which have been ſold for 4, 8, 10 and 15*l.* a-piece; which are as black as Ebony, and very laſting and durable. The Aſhes are as ſoft as Earth, and are commonly cut in Pieces by the Workmens Spades, which as ſoon as flung up into the open Air, fall away into Duſt; but all the reſt, even the Willows themſelves, which are ſofter than Aſhes, preſerve their Subſtance and Texture to this Day. I have ſeen ſome Fir-Trees, that as they have laid all along, after that they were fallen, have ſtruck up great Branches from their Sides, which have grown into the Thickneſs and Height of conſiderable Trees.

It is very obſervable, and manifeſtly evident, that many of thoſe Trees of all ſorts have been burnt, but eſpecially the Fir-Trees, ſome quite through, and ſome all on a ſide, ſome have been found chopp'd and ſquared, ſome bored through, others half riven with great wooden Wedges, and Stones in them, and broken Ax-heads, ſomewhat like Sacrificing Axes in Shape; and all this in ſuch Places, and at ſuch Depths, as could never be opened from the Deſtruction of this Foreſt until the Time of the Drainage. Near a great Root in the Pariſh of *Hatfield*, were found 8 or 9 Coins of ſome of the *Roman* Emperors, but exceedingly conſumed and defaced with Time; and it is obſervable, that upon the Confines of this low Countrey, between *Burningham* and *Brumby* in *Lincolnſhire*, are ſeveral great Hills of looſe Sand, under which (as they are yearly worn and blown away with the Sand) are diſcovered many Roots of great Firs, with the Impreſſes of the Ax as freſh upon them, as if they had but been cut down a few Weeks; which I have ſeveral Times taken Notice of.

Hazle Nuts and Acorns have frequently been found at the Bottom of the Soil of thoſe Levels and Moors, and Fire-Tree Apples, or Cones, in great Quantities, by whole Buſhels together. And at the very Bottom of a new River or Drain, that the Drainers cut, (almoſt 100 Yards wide, and 4 or 5 Miles long, at the Charge of above 30000*l.* beſides the great Sluice at the End thereof, which coſt near 30000*l.* more) were found old Trees ſquared and cut, Rails, Stoups, Bars, old Links of Chains, Horſe-heads; an old Ax ſomewhat like a Battle-Ax, two or three Coins of the Emperor *Veſpaſian*; one of which I have ſeen, with the Emperor's Head on the one ſide, and a Spread Eagle on the other; but that which is more obſervable, is, that the very Ground at the Bottom of the River was found in ſome Places to lye in Rigg and Fur, manifeſting thereby that it had been plow'd and tilled in former Days.

Mr. *Edw. Canby* told me, that about 50 Years ago, under a great Tree in this Pariſh, was found an old-ſhaped Knife, with a Haft of a very hard black ſort of Wood, which had a Cap of Copper or Braſs on the one End, and a Hoop of the ſame Metal on the other End, where the Blade went into it; which Blade ſoon mouldering away, he got a new Blade put therein, with this Diſtich upon it.

Ever ſince No's *Flood was I left,*
My old Blade's conſum'd, but this is the Haft.

The ſame Gentleman alſo found an Oak Tree within his Moors 40 Yards long, 4 Yards in Diameter at the great end, 3 Yards and a Foot in the middle, and two Yards over at the ſmall end; ſo that the Tree ſeems to have been as long again; for which he was proffer'd 20*l.* At another Time he found a Fir-Tree 36 Yards long, beſides the computed length thereof, which might well be 15 Yards more. About 50 Years ago, at the Bottom of a Turf-pit, was found a Man lying at his length, with his Head upon his Arm, as in a common Poſture of Sleep, whoſe

Skin being as it were tann'd by the Moor-Water, preſerved his Shape intire, but within, his Fleſh and moſt of his Bones were conſumed and gone; an Arm of whom is now in the Poſſeſſion of Dr. *Nat. Johnſon.*

Though theſe Things may ſeem ſtrange, yet many Authors have related the ſame.

Cambden and others have told us, and it is a Thing well known, that moſt of the great Moraſſes, Moſſes, Fens and Bogs in *Somerſetſhire*, *Cheſhire*, *Lancaſhire*, *Weſtmoreland*, *Yorkſhire*, *Staffordſhire*, *Lincolnſhire*, and other Counties in *England*, are full of the Roots and Bodies of great Trees, moſt of which are Fir; and that they have the ſame Poſitions and Impreſſions of the Fire and Ax upon them, that thoſe have.

Giraldus Cambrenſis tells us, that in King *Henry* the Second's Days, by the Force of extraordinary Storms, the Sands were driven ſo much off from the Sea-ſhores, in *Pembrokeſhire*, that under them were diſcovered great Numbers of the Roots and Bodies of Trees in their natural Poſtures, with the Stroaks of the Ax as freſh upon them, as if they had but been cut down yeſterday, with a very black Earth, and ſome Blocks like unto Ebony; the ſame were diſcover'd again at *Neugall*, in the ſame County in 1590, and in *Cardiganſhire*, and other Places ſince.

Dr. *Plot* mentions the like Roots and Trees to be found in *Shebben* Pool, the old *Pewit* Pool, and at *Layton* and other Places in *Staffordſhire*; and from their natural Situations and Poſtures concludes, that they did certainly grow there.

Dr. *Leigh*, in his Hiſtory of *Cheſhire*, obſerves, that in the draining of *Martin Meer* (which was performed but a few Years ago) were found Multitudes of the Roots and Bodies of great Firs, in their natural Poſtures, with great Quantities of their Cones, 8 Canoes, ſuch as the old *Britains* ſail'd in, and in another Moor was found a Braſs Kettle, Beads of Amber, a ſmall Mill-ſtone, the whole Head of an *Hippopotamus*, and Human Bodies intire and uncorrupted. I ſuppoſe he means, as to outward Appearance.

Many Places of the Soil of *Angleſea* and *Man*, as alſo of the Bogs of *Ireland*, are likewiſe full of Roots and Trees; but of what ſort I have not yet learn'd.

Verſtegan tells us, that in many Places of the Moors and Moraſſes of the *Netherlands*, great Fir-Trees are commonly found with their Tops lying to the North-Eaſt, juſt as they do in theſe Levels, and *Helmont* mentions the *Peel* there, a Turf more of 9 Miles broad.

I have likewiſe read in ſome of the *French* Naturaliſts, I think in Monſieur *de la Ferr*, that Trees and Roots are alſo frequently found in the Low Grounds, Levels and Moraſſes of *France*, *Switzerland* and *Savoy*.

Rammazzini aſſures us, that in the Territories of *Modena* (which are ſeveral Miles long and broad, and at preſent a moſt fruitful dry Countrey, tho' in the Time of the *Cæſars* it was nothing but a great Lake) are found at 30, 40, and 50 Foot deep, the Soil of a low marſhy Country,

Country, full of Sedge, Reeds, Shrubs, Roots, Trees, Nuts, Ears of Corn, Leaves of Trees, Branches and Boughs of Oaks, Elms, Wall-nuts, Aſhes, Willows, and the very Trees themſelves, ſome broke, ſome whole, ſome ſtanding upright, ſome lying at their Length, *&c.* with old Coins of the *Roman* Emperors, old Marbles and Stones ſquared, cut, carved, and wrought, with the Hands of Men, *&c.*

Moſt Men refer all this to *Noah*'s Flood; but if ſo, how comes it that the Trees and their Roots lie ſo near to one another, and why lengthways, from South Weſt to North-Eaſt? Why ſome of them burnt, ſome chopt, ſome riven, ſome ſquared, ſome bored through? Why the Soil at the very Bottom of a great River lying in Rigg and Fur? And why the Coins of *Roman* Emperors found in thoſe Places, *&c.*? But I am of Opinion, that all thoſe Trees grew in the very Places where we now find them, both in this Country, and all others where they are found; to which I have heard but two Objections: The firſt, That *Cæſar* expreſly ſays, that no Fir-trees in his Time grew in *Britain:* But that *Cæſar* may have been miſtaken in this Point, may appear from what he mentions of the next Tree, the *Beech*, which he excludes alſo; and which is ſo common in every Part of this Nation: And in an old Deed relating to this very Chace, Fir-trees or Buſhes are mention'd as growing here and there one, about 300 Years ago; and it is very well known, that there was a Tree of the very ſame Wood growing upon *Hatfield* Moor Side within theſe 30 Years, which a while after was cut down, it being the very laſt of that Kind that was ſeen flouriſhing here.

The ſecond Objection is, That thoſe ſorts of Trees grow always on high Mountains and Rocks, and never thrive, nor naturally grow upon ſuch Low Grounds and Moraſſes, as theſe are, where we now find them; but though they do indeed in all cold Countries of the North, thrive beſt there upon the hardeſt Rocks and Mountains, yet are they ſometimes ſeen even there plentiful and great, in the Low Moraſſes of *Liefland*, *Courland*, *Pomerania*, and other Countries thereabouts; and in the Low Foreſts and Woods weſt of *New England*, as I have heard Travellers affirm, what theſe Trees require, is a ſandy Soil; and if it lie never ſo high, or never ſo low, there they will grow, and there it is natural to them. And as the Reverend Mr. *Earat* of *Hatfield* lately obſerv'd in the digging of a Pit of a great Decoy in theſe Levels, the Roots of the Firrs always ſtood in the Sand, and the Oaks in the Clay; and I have obſerved the ſame in Multitudes of Places of theſe Commons.

The Reaſon why all theſe Woods were deſtroy'd, we may learn from the *Roman* Hiſtorians; who frequently tell us, that when their Armies and Generals purſued the wild *Britains*, that they always fled into the Faſtneſſes of miry Woods and low watery Foreſts. *Cæſar* himſelf confeſſes the ſame; and ſays, that *Caſſibelan* and his *Britains*, after their Defeat, paſſed the *Thames*, and fled into ſuch low Moraſſes and Woods,

that there was no Poſſibility of following them. We find alſo, that the ſtout Nation of the *Silures* did the ſame when they were ſet upon by *Oſtorius* and *Agricola*. The like did *Venutius* King of the *Brigantes*, who fled into the great woody Moraſſes of this Country, and perhaps into thoſe very ſame that formerly overſpread theſe Levels. And *Herodian* tells us, that it was the Cuſtom of the wild *Britains* to keep in the fenny Bogs and thick marſhy Woods, and when Opportunity offer'd, to iſſue out, and fall upon the *Romans*, who were at length ſo plagued with them, that they were forced to iſſue out Orders for the deſtroying and cutting down of all the Woods and Foreſts in *Britain*, eſpecially of all thoſe that grew upon low Ground and Moraſſes. This Order, I think, is mention'd in *Vopiſcus*; and that they were accordingly thereupon cut down, is evident in many Writers, who tell us, that when *Suetonius Paulinus* conquer'd *Angleſea*, he cut down all the Woods there. *Galen* tells us, that the *Romans* kept their Soldiers continually employed in cutting down of Woods, draining of Marſhes and Fens, and in paving of Bogs. It is manifeſt alſo, that they did not only do this themſelves, but alſo impoſed the ſame Taſk upon the *Britains*; for *Galgacus* in his Speech to his Soldiers, tells them, that the *Romans* made Slaves of them, and wore out their Bodies in cutting down of Woods and in cleanſing of Bogs, amidſt a thouſand Stripes and Indignities; and *Dion Caſſius* tells us, that the Emperor *Severus* loſt 50000 of his Men in a few Years time, in cutting down of the Woods, and cleanſing of the Fens and Moraſſes of the Nation.

As I have ſhew'd in general, that the *Romans* were the Deſtroyers of all thoſe great Woods and Foreſts, ſo now I ſhall ſhew in particular, that they actually were in this part of the Country, and deſtroy'd this great and beautiful Foreſt of *Hatfield-Chace*.

The common Road of the *Romans* out of the South into the North, was formerly from *Lindum* (*Lincoln*) to *Segelocum* (*Little burrow* upon *Trent*) and from thence to *Danum* (*Doncaſter*, where they kept a ſtanding Garriſon of *Criſpinian* Horſe) a little off on the Eaſt and North-Eaſt of their Road between the two laſt named Towns, lay the Borders of the great Foreſt, which ſwarm'd with wild *Britains*, who were continually making their Sallies out of the ſame, and their Retreats into it again, intercepting their Proviſions, taking and deſtroying their Carriages, killing their Allies and Paſſengers, and diſturbing their Garriſons; which at length ſo enraged the *Romans*, that they were reſolved to deſtroy it; and that they might do the ſame more effectually, they marched with a great Army againſt the ſame, and encamped upon a great Heath or Moor, not far from *Finningly*, (as by their Fortifications there yet to be ſeen, is apparent) where it is probable, that a great Battle enſued; for hard by, is a little Town, called *Oſterfield*. Now as the latter part of the Word is never us'd to be added to any other, but where there hath been a Battle; ſo the former ſeems to tells us what *Roman* General it was that fought, to wit, the famous *Oſtorius*, whom all the *Roman* Hiſtorians.

Hiſtorians aſſure us, was in thoſe Parts. But who got the Victory, is not ſo eaſy to be judged of, though, no Doubt, it was the valiant *Romans*, who beſides the Multitudes of the *Britains* that they ſlew, drove the reſt back into the great Foreſt and Wood, that cover'd all this low Country: Whereupon the *Romans*, that they might both deſtroy it and the Enemy the eaſier, took the Opportunity of a ſtrong South-weſt Wind, and ſet great Fires therein, which taking hold of the Fir-trees, burnt like Pitch, and conſumed infinite Numbers of them; then when the Fir had done what Miſchief and Execution it could, the *Romans* brought their Army nearer, and with whole Legions of captive *Britains* chopp'd and cut down moſt of the Trees, that were yet left ſtanding, leaving only here and there ſome great ones untouched, as Monuments of their Fury, and unneedful of their Labour; which being deſtitute of the Support of the Underwood, and of their neighbouring Trees, were eaſily overthrown by the ſtrong Wind; all which Trees falling croſs the Rivers that formerly ran through this Low Country, ſoon damm'd up the ſame, turned it into a great Lake, and gave Origin to the great Turf Moors that are here, by the Gyrations and Workings of the Waters, the Precipitation there-from of terreſtrial Matter, the Conſumption and Putrefaction of rotten Boughs and Branches, and the vaſt Increaſe of thick Water Moſs, which wonderfully flouriſhes, and grows upon ſuch rotten Grounds; which, even now, ſince the Drainage, and ſince that the Country is laid dry for many Miles round about, yet for all that, are ſo turgid with Water, and ſo ſoft and rotten, that they will ſcarce bear Men to walk upon them.

Hence it is, that old *Roman* Coins, old *Roman* Ax-heads, *&c.* have been found by thoſe Roots, and Trees that lie at the Bottom of theſe Moors and Levels. Hence it is, that in all theſe Grounds are found great Numbers of Trees, that are burnt, ſome in two, and ſome length-ways, others hewn and chopp'd. Hence it is, that they lie by their own proper Roots with their Tops North-Eaſt: Hence it is, that ſome of the greateſt Trees are found with their Roots on, and others, as they have laid all along, have had Branches growing out of the Sides, unto the Thickneſs and Height of conſiderable Trees. Hence it is, that both the Clay and Moor Soil of the Country, is in ſome Places 2 or 3 Yards higher than it was formerly, by the growing up of the ſame, and the daily Warp that the Rivers continually caſt thereon, *&c.*

As the *Romans* were the Deſtroyers of this great Foreſt, ſo were they likewiſe of all thoſe others that formerly grew upon the Low Countries of *Cheſhire*, *Lancaſhire*, *Yorkſhire*, *Lincolnſhire*, *Staffordſhire*, *Somerſetſhire*, &c. and of the very Countries before-mention'd beyond Sea, where ſuch Trees are found. But as the *Romans* were not much in *Wales*, the *Iſle of Man*, nor *Ireland*, ſo it cannot be ſuppoſed that it ſhould be them that cut down their Woods; but though they did not, yet

yet others did, for *Hollinſhead* and others of our Hiſtorians tell us, that *Edward* the 1*ſt* being not able to get near the *Welſh* to fight them, by their Continuance and Skulking in boggy Woods, commanded them all to be deſtroyed by Fire and Ax: And I doubt not at all, but that the Roots and Trees, before mention'd by *Cambrenſis* in *Pembrokeſhire*, were the Relicts of ſome of thoſe, that were then deſtroy'd: And as for thoſe in *Man*, and other Iſlands, they have all been cut down in the Time of War, and have laid till they were grown over with the Soil of the neighbouring Grounds: And as for thoſe that are found in the Bogs of *Ireland*, many of our Hiſtorians expreſly ſay, that *Henry* the Second, when he conquer'd it, cut down all the Woods that grew upon the Low Countries thereof, the better to ſecure his Conqueſt and Poſſeſſion of the ſame, to keep the Country in a ſettled Peace, and to diſarm the Enemy, who commonly truſting to ſuch Advantages, are apt to rebel.

I may alſo add, that it is a very common Thing for Generals, even to this very Day, to deſtroy all the Woods that grow upon advantageous Places and Faſtneſſes in an Enemy's Country, if they intend to keep it; and that they always do it with Fire and Ax.

— *on the* ſame, *by the* ſame. n. 277. p. 1073.

2.] I have received ſome farther Informations about the *Fir-Trees* of *Hatfield-Chace*. I have been told by ſeveral Gentlemen, that about 20 Years ago, one *Sanderſon*, of *Hatfield*, died, aged near 80 Years, whoſe Father, much of the ſame Age, did frequently aſſure him, and other Gentlemen that were curious in the Matter, that he could very well remember many Hundreds of great Fir-trees, ſtanding one here and another there, in a languiſhing decaying Condition, half as high as Houſes, and ſome higher, whoſe Tops were all dead, yet their Boughs and Branches always green and flouriſhing, growing all of them in theſe Levels: And *John Hatfield* of *Hatfield*, Eſq; who is not above 40 Years of Age, has by him a large Twig that his Father pluck'd off from the Sprout of a green and flouriſhing Shrub of Fir, that grew from the great Root of one of the ſame kind in theſe Commons. And an old Man of *Croul* tells me, that he has heard his Father ſay, that he could remember Multitudes of Shrubs and ſmall Fir-trees growing here, while this Country was a Chace, and while the Vert was preſerved, before the Drainage. And in many old Charters, that I have ſeen, of *Roger de Mowbray*, Lord of *Axholm*, who lived in the Year 1100, relating to *Hurſt*, *Bell-wood*, *Roſs*, *Santoft*, &c. it appears, that then all theſe Places were cover'd with a great old decaying Foreſt or Wood; and not them only, but alſo all that low Common between *Croul* Cauſey and *Authrop upon Trent*; and though there be not one Stick of any ſuch Thing now to be ſeen, yet it is not only plainly manifeſt, that the ſame was true, from the Roots there found, but alſo from the ſaid Roots, that moſt of the Trees that then grew there, were Firs. All which, were but the After-growth, and Relicts of the great Foreſt, that was deſtroyed by the *Romans*.

VII. There happen'd an Inundation at *Dagenham* and *Havering* in *Eſſex*, about four or five Years ago, by a Breach in the *Thames* Wall at an extraordinary high Tide; and by Means of the great Violence of the Water, a large Channel was torn up, or Paſſage for the Water of 100 Yards wide, and 20 Feet deep in ſome Places; and in ſome more, ſome leſs. By which Means a great Number of Trees were laid bare, that had been there interred many Ages before.

Of Subterraneous Trees at Dagenham *in* Eſſex, *by Mr.* W. Derham. n. 335. p. 478.

The Trees were all of one Sort, except only one, which was manifeſtly a large Oak, with the greateſt Part of its Bark on, and ſome of its Head and Roots. The reſt of the Trees were taken to be *Yew*, from the Hardneſs, Roughneſs, and Weight of the Wood, notwithſtanding we have no *Yew* growing any where thereabouts; and it ſeem'd ſtrange to me, that *Yew* ſhould grow in ſuch vaſt Quantities, in ſuch a Soil, and ſo near the brackiſh Waters. Some took it to be *Horn-beam*, which grows plentifully alſo with us in the higher Lands (but I do not remember to have ſeen it in watery Places near us) but I rather incline to the Opinion of its being *Alder*, (which grows plentifully by our Freſh-Water Brooks) the Grain of the Wood, and Manner in which the Boughs grow, *&c.* much more reſembling that of *Alder*, than *Horn-beam*.

By lying ſo long under Ground, the Trees are become black and hard, and their Fibres are ſo tough, that one may as eaſily break a Wire of the ſame Size, as any of thoſe Fibres. This Toughneſs they maintain, if the Wood be kept dry; but by drying, thoſe Trees become cracked, and very flawy within, but look ſound outwardly, and with Difficulty yield to Wedges. But the Trees lying in the Marſhes, which are covered by every Flood, and laid bare by every Ebb, in a ſhort Time become very rotten.

There is no doubt, but thoſe Trees grew in the Place where they now lie, and that in vaſt Multitudes; they lying ſo thick upon, or near one another, that in many Places I could ſtep from one to another. And there is great Reaſon to think, that not only the Marſhes, which are now overflow'd (which are about 1000 Acres) are covered underneath with thoſe Subterraneous Trees, but alſo all the Marſhes along by the River Side, for ſeveral Miles: For we diſcover theſe Trees all along the *Thames* Side over againſt *Rainham*, *Wennington*, *Purfleet*, and other Places: And in the Breach that happened at *Weſt Thorrock* about 21 Years ago, they were waſhed out in as great Numbers (as I have been inform'd) and of the ſame kind of Wood, as thoſe found lately in *Dagenham* and *Havering* Levels.

Theſe Trees are of different Sizes; ſome above a Foot Diameter, ſome leſs. I met with two of the leſſer Sort, ſtanding upright, in the ſame Poſture in which they grew; their Tops juſt above Low-Water, and their Bottoms (at leaſt the Bottom of the Channel) at 16 Feet Depth. We endeavoured to draw them out, but could not do it with all

all our Strength. They ſeemed to be about 2 Inches Diameter in their Trunk, had ſome of their Boughs on, were dead, and in all Likelihood, being young and light, eſcaped the Force of what threw the other more large and unweildy ones down.

Moſt of the Trees had their *Roots* on, and many of them their *Boughs*, and ſome a Part of their *Bark*. There was only one that I perceived had any Signs of the *Ax*, and its Head had been lopped off.

I could ſee all along the Shores vaſt Numbers of the *Stumps* of thoſe Subterraneous Trees, remaining in the very ſame Poſture in which they grew, with their Roots running ſome down, ſome branching and ſpreading about in the Earth, as Trees growing in the Earth commonly are ſeen to do. Some of thoſe Stumps I thought had Signs of the Ax, and moſt of them were flat at top, as if cut off at the Surface of the Earth; but being rotten and battered, I could not fully ſatisfy my ſelf, whether the Trees had been cut, or broken off.

The *Soil*, in which all thoſe Trees grew, was a black oozy Earth, full of the Roots of Reed; on the Surface of which oozy Earth the Trees lay proſtrate, and over them a Covering of grey Mould, of the ſelf ſame Colour and Conſiſtence with the dry Sediment, or Mud, which the Water leaves behind it at this Day. This Covering of grey Earth is about 7 or 8 Feet thick, in ſome Places 12 Feet or more, in ſome leſs; at which Depths the Trees generally lie.

Another Thing I took notice of, was the *Poſture* in which the Trees lay, which was indeed in no kind of Order, but ſome this way; ſome that, and many of them a-croſs: Only in one or two Places I obſerved they lay more orderly, with their Heads for the moſt Part towards the North, as if they had been blown down by a Southerly Wind, which exerts a pretty ſtrong Force upon that Shore.

As to the *Age* in which thoſe Trees were interred, it is hard to determine. Many think they have laid in that Subterraneous State ever ſince *Noah*'s *Flood*. But although I have not the leaſt Doubt, but that at this Day we have many Remains of the Spoils of that Deluge, even in the higheſt Mountains; yet I rather think theſe Trees to be the Ruins of ſome later Age, occaſioned by ſome extraordinary Inundations of the River of *Thames*, or by ſome Storms, which blow ſharply upon this Shore: Either of which Acts of Violence might be able to root up, and tumble down Trees growing in ſo lax a Soil, as theſe manifeſtly grew in at that Time. And as for extraordinary *Inundations* of the *Thames*, there is at this Day a Mark, which, if occaſioned by an Inundation, was the Mark of an Inundation very prodigious, beyond all ever known to have been in that River; and that is a *Bed of Shells*, if not a kind of Marble too, lying croſs the Highway on the Deſcent near *Stifford-bridge*, going from *S. Okendon*.

Below this Bed of Shells, at above 50 or 60 Yards Diſtance in the Bottom of the Valley, runs a Brook that empties itſelf into the *Thames* at *Purfleet*, about three Miles from thence; which Brook ebbs and flows

flows as the *Thames* does, but not at any certain Height, by Reaſon of Mills ſtanding thereon; but above a pretty High-water in the Brook, the Surface of the Bed of Shells I find to lie above 20 Feet perpendicular. Conſequently if this Bed of Shells was repoſited in that Place by an Inundation of the *Thames*, that Inundation muſt be ſuch, as would have drowned a vaſt deal of the adjacent Countrey, and have over-topped the Trees by the River, in *Weſt-Thorrock*, *Dagenham*, and the other Marſhes, and probably by that Means overturned them.

Now had theſe Trees been left there by the *Univerſal Deluge*, we ſhould not find the Bed of Earth, in which they grew, ſo entire and undiſturbed, as it manifeſtly is at this Day, a ſpongy, light, oozy Soil, full of Reed-root; and I aſſure my ſelf (although I never try'd it) of much leſs Specific Gravity than the *Stratum* above it is. Whereas I can from Experiments affirm, that in the three Places where I have tried it, the *Strata* are in a ſurprizing Manner gradually ſpecifically heavier and heavier, the lower and lower they lie.

As for the *Manner how theſe Trees came to be interred*, this I take to be from the gradual Increaſe of the Mud, or Sediment, which every Tide of the *Thames* leaves behind it. I preſume, thoſe Trees might be thrown down before the Walls or Banks were made, that keep the *Thames* out of the Marſhes; and then thoſe Trees were over-flown every Tide. And by Reaſon they lay thick, would ſoon gather a great deal of the Sediment. And after the *Thames* Walls were made, every Breach in them, and Inundation would leave great Quantities of Sediment behind it; as I found in going over ſome of the Marſhes, ſoon after the late Breach, where I found the Mud generally above my Shoes, and in many Places above my Knees. And it is a Practice among us (of which we have divers Inſtances) that where a Breach would coſt more to ſtop, than the Lands over-flown will countervail, there to leave the Lands to the Mercy of the *Thames*; which by gradually growing higher and higher, by the Additions of Sediment, will in Time ſhut out the Water of the River, all except the higheſt Tides. And theſe Lands they call *Saltings*, when covered with Graſs; or elſe they become *Reed-ground*, &c.

That it was the Sediment of the *Thames* that buried theſe Trees, is farther manifeſt from what I ſaid before, of the Likeneſs of the Earth above them, in all Reſpects, to the Sediment the River now lets fall, when dry, which may be obſerved to conſiſt of many diſtinct Layers; ſome $\frac{2}{10}$ of an Inch think, ſome leſs, and ſome ſcarce $\frac{1}{10}$ of an Inch. All which ſeveral Layers are, no doubt, the ſeveral Quantities, which every Tide left behind it. This Sediment, when dry'd by the Sun and Wind, becomes tough and hard, and looketh like a grey *Lapis Sciſſilis* or *Slate*, diviſible into many Plates or Layers. And what if we ſhould aſcribe the Conformation of *Slate*, *Muſcovia-glaſs*, and other the like laminated Concretions, to a like Work of Nature, by adding new Layers of ſuch Petrifactions, and Particles, as the Foſſil is made of?

I preſume there will be no doubt, but that the ſubterraneous Wood receives its Blackneſs from Vitriolic Juices in the Earth. I have try'd the Experiment, and find that *Alder-Wood*, whether green or old, becomes blackiſh, much of the ſame Colour as the Wood mentioned in this Paper, in a Solution of Copperas. Which is not only an Argument, that the Blackneſs of the Wood is owing to Vitriol, but alſo that the Wood is *Alder*, or ſome ſuch like Wood, that will become black with Vitriol; for I am informed that all ſubterraneous Wood is not black, particularly *Fir*. I have tried *Horn-beam* ſince, after the ſame Manner, and find that alſo becomes black, as the *Alder* doth.

Of ſtrange Bones *dug up near* Canterbury. *And of the* Iſthmus *between* Dover *and* Calais, *&c. by Mr.* W. Somner. n. 272. p. 882.

Fig. 26, 27.

VIII. 1.] Mr. *John Somner*, in the Month of *September* 1668. ſinking a Well at a new Houſe of his in *Chartham*, a Village about three Miles from *Canterbury*, towards *Aſhford*, on a Shelving Ground or Bank-ſide, within 12 Rods of the River, running from thence to *Canterbury*, and ſo to *Sandwich* Haven; and digging for that Purpoſe above ſeventeen Foot deep, through gravelly and chalky Ground, and two Foot into the Springs, there met with, and turned up a Parcel of ſtrange and monſtrous Bones, ſome whole, ſome broken, together with four Teeth, perfect and ſound, but in a Manner petrified, and turned into Stone; weighing (each Tooth) ſomething above half a Pound, almoſt as big (ſome of them) as a Man's Fiſt: Cheek-Teeth, or Grinders, as to the Form, they are all, not much unlike, (but for the Bigneſs) the Grinders of a Man. I remember to have read in *Ludovicus Vives*, of ſuch a Tooth, but a little bigger *(dens molaris pugno major)* which was ſhewed to him for one of St. *Chriſtopher*'s Teeth, and was kept in a Church that bore his Name. Juſt ſuch another Tooth, *of the Bigneſs*, he ſaith, *of an ordinary Fiſt*, was ſeen by *Acoſta* in the *Indies*, digged out of the Ground, in one of their Houſes there, with many other Bones; which put together repreſented a Man of a formidable, or as he ſpeaks, *deformed Bigneſs*; as he judged of it. And ſo muſt we have judged of theſe Teeth, and of the Body to which they belonged, had not other Bones have been found with them, which could not be Man's Bones. Some that have ſeen them, by the Teeth and ſome other Circumſtances, are of Opinion, that they are the Bones of an *Hippopotamus*, or *Equus Fluvialis*; that is, a *River Horſe*; for a *Sea Horſe*, as commonly underſtood and exhibited, is a fictitious Thing. Yet *Pliny* makes *Hippopotamum (mari, terræ, amni communem)* to belong to *Sea*, *Land*, and *Rivers*. But what the Differences and Properties of each kind are, I leave to others to enquire. The Earth or Mould about them, and in which they all lay, being like a Sea-Earth, or Fulling-Earth, not a Stone in it, unleſs you dig three Foot deeper, and then it riſes a perfect Gravel.

It is not eaſy to define or determine what the Creature was; and doubtleſs dubious enough it is, whether of the two, the Sea or the Land, may more rightly lay Claim to it. But I am of Opinion, that it is ſome Marine

rine, or Sea-bred Creature, to which the Land can of Right lay no Claim. But ſuppoſing it a Sea-bred Creature, how then (will ſome ſay) ſhould it poſſibly come there? and at ſuch a Depth under Ground? I anſwer, firſt, with as little Wonder as a Land-creature ſhould, which who with Reaſon can imagine to have ever had at firſt ſo deep a Burial? Next, I ſay, the Mould, Soil, or Earth, wherein it lay, was altogether miry, like to that *cænum* (*ooſe*, ſome call it) on many Parts of the Sea-coaſt, both in *England* and abroad. But how poſſibly (will it be ſaid) a Sea-creature, when found at ſo remote a Diſtance from the Sea? For Solution (if it may be) of this, and the like incidental Doubts, and removing all Rubs out of the Way of this Conjecture; I ſhall conſider the four following Queries:

1. Whether the Situation and Condition, Face and Figure, of the Place, may poſſibly admit of the Sea's once inſinuating it ſelf thither?

2. Whether (that Poſſibility being granted, or evinced) the Sea did ever actually inſinuate it ſelf ſo far as to this Place, and when?

3. How in Probability, and when, this Valley or Level, being once Sea-land, ſhould come to be ſo quite deſerted and forſaken of the Sea, as it is at this Day; the Sea not approaching by ſo many, a dozen Miles, or more?

4. By what Means the Sea, once having its Play there, this Creature comes to lodge, and be found ſo deep in the Ground, and under ſuch a ſhelving Bank?

1. As for the firſt (the Place's Capacity and Aptitude for the Sea's Influx or Inſinuation) ſuch as know the Situation, withal, cannot but know, and muſt agree it to be ſo. As for Strangers, and ſuch as are unacquainted with the Place, they are to be informed, that the Place (the *locus loci*) we are upon, is a Part of that wide, fair, and fruitful Level, or Valley, extending it ſelf not leſs than twenty Miles in Length, between a continued Series and range of Hills, Downs, or high Grounds, lying at a pretty Diſtance each from other all the Way; beginning at the *Eaſt Kentiſh* Shore, and ſtretching it ſelf weſtward by *Sandwich*, *Fordwich*, *Canterbury*, *Chartham*, *Chilham*, *Godmerſham*, *Wy*, *Aſhford*, ſometimes in a direct, ſometimes in a winding Courſe, as far at length, as to that famous ſpacious Level of *Romney-marſh*; and is waſh'd and water'd all along, at leaſt from about *Aſhford*, by a ſweet and pleaſant River running through the midſt of it, as far as to *Sandwich*, and there by the Creek, or Haven, emptying it ſelf into the Sea: Nothing at all of Obſtruction, by the Interpoſition of Hills, or high Grounds, hindering or controlling the Sea's free Play and Paſſage for ſo many Miles together. The Place then, with the Parts, the Tract above and below it, from the Condition or Conſtitution of it, is plainly not unapt or uncapable of the Sea's Inſinuation and Influence.

If any ſhall object, *Canterbury*'s being in the Way, as an Obſtruction or Bar; they are eaſily enough anſwer'd. For although that City ſeems (and indeed is at this Day) for the moſt part ſomewhat elevated above the Pitch of the reſt of the Valley or Level we are upon; yet not ſo much as to defend it ſelf many Times from Floods, and Overflowings, in the lower, and moſt depreſſed Parts of it, even by the Springs it ſtands upon; towards the helping whereof, by the Care and Providence of former Ages, it is very certain, and by digging Wells, Vaults, Cellars, and the like, daily experimented, that the moſt Part of the City, not excepting the very Heart and Center of it, is made and raiſed Ground: The Tokens of Foundations upon Foundations, to a very conſiderable Depth, daily appearing, and the Ground (as at *Amſterdam*, *Venice*, and elſewhere) for ſupporting Superſtructures, in ſeveral Places often ſtuck and ſtuffed with Piles of Wood, or long Poles and Stakes, forced into the Ground, as Wells and Cellar-diggers have informed me. And, as if, where now the Bull-ſtake Market-place is kept, the River had ſometime had its Courſe or Current, Pits, and other like Tanner's Utenſils, have, not many Years ſince, been met withal in digging for Cellars thereabouts. To this let me add, that my next Neighbour in *Caſtle-ſtreet*, within theſe thirty Years ſinking a Cellar, did a good Depth (*five or ſix foot deep*) light upon, and was put to ſome Stop and Stand in his Work by, a ſtrong and well-couched arched Piece of *Roman* Tile or Brick, which he was fain to take, or break aſunder, and remove, before he could proceed. However, then *Canterbury* may now ſeem to ſtand in the *Æſtuary*'s Way, yet Time was, when in Probability it did not; when, I mean, the Place, the Soil, which now the City occupies, as the reſt of the whole Valley both above and below it, was of too low a Pitch, to be an Obſtacle to it.

As to the ſecond Enquiry, (whether probably the Sea did ever actually inſinuate it ſelf ſo far as to this Place, and when) the Anſwer is not ſo eaſy: Record of it, we have none. The beſt and eldeſt Account we have now of the Condition, Site, and Conſtitution, of theſe our Eaſtern Parts and Tract, we owe to *Julius Cæſar*, and the *Romans* after him; from whom we have not the leaſt Hint of any ſuch Thing, but rather the contrary; both the Sea-coaſt and Inland Parts, by his, and their Relation, bearing in a Manner one and the ſame Face and Figure then, as now. However, that the Level we are upon, was ſometime an *Æſtuary*, or Arm of the Sea, ſeveral *Criteria*, or Tokens are not wanting: For Example, beſides what may be argued and inferr'd from this Parcel of ſtrange Teeth and Bones now under Conſideration; much (as I conceive) there is of Probability for it, reſulting from our River's Name of *Stoure* more anciently, not ſeldom both called and written *Æſtur*, *Æſture*, &c. which I doubt not to proceed and come from the Latin *Æſtuarium*, and in proceſs of Time to have been corrupted and contracted into *Sture* and *Stoure*; giving name in part to *Stourmouth*, a Place about ſix Miles Eaſtward from *Canterbury*;

ſo

ſo called from the River's diſemboguing there into the Sea or Salt-water flowing up thither, as alſo giving Name to the Manor of the Archbiſhop's, at this Day, and for ſome Ages paſt called *Weſtgate-Court*, at *Canterbury*; but more anciently, as in the Conqueror's Time (witneſs *Domeſday* Book) called the Manor of *Eſture* and *Eſtureſate*, from its Situation by the *Sture* or *Stoure*. From which Occaſion, doubtleſs, the late Lord *Finch*'s Seat in———about five or ſix Miles nearer to the Spring-Head, at this Day vulgarly miſcalled *Eaſt-Steward*, is of old ſometimes called *Eſture*, ſometimes *Et ſture*. From *Saxon* Monuments and Records, I could eaſily trace the Name up to a very high Date, by many Examples.

But to proceed to other *Criteria*; as by the Teeth and Bones now under Conſideration, we have an Inſtance on that Side of the Valley for the Probability of the Sea's *quondam* Occupation of it; ſo I ſhall give here another no leſs remarkable from the other, or oppoſite ſide of it. By credible Relation, then, at a Place called *Webſtere*, an obſcure Village about three Miles from *Canterbury*, Eaſtward, lying under the Brow of the Hill ſtretching out by *Upſtreete*, as far as to the Weſt-end of *Sarr-wall*, by which you make your Entrance into *Thanet*, upon the like Occaſion to that here at *Chartham*, (the digging or ſinking of a Well) at a very great Depth, ſtore of Oyſters and other-like ſhells, together with an Iron Anchor, firm and unimpaired, were found and turned up in our Time. The like I have been told of an Anchor in our Days, digged up at *Broomedowne*, on the ſame ſide of the Level, ſomewhat above *Canterbury*, Weſtward.

As to the third Query, how in Probability, and when this Valley or Level, being once Sea-land, ſhould come to be ſo quite deſerted, and forſaken of the Sea, as it is at this Day, the Sea not approaching it by ſo many, a dozen Miles, or more? In anſwer whereof, I muſt needs ſay and grant, that in caſe this Level were once Sea, an *Æſtuary* I mean, or Arm of it; ſo very long it was ago, as we may not reaſonably think, that *Canterbury* (whether as a city, or never ſo mean a *Pagus*, or Village) was then in *rerum natura*, or a Place inhabited; which happily it may have been, if not as long as *Julius Cæſar*'s Days, yet undoubtedly not long after. For an Account we have of it (as of ſome other Places in *Kent*) in the *Romans* Time, from *Ptolomy*, *Antoninus*'s *Itinerary*, and elſewhere. Now elder Records, either of *Kent*, or of *Britain*, that we may confide in as Authentic, we have none, that I know of, before the *Romans* Time. We muſt either, therefore, throw off all further Inquiry, or elſe caſt about for Information as we can. Such as are for this latter, will tell you, that the World is very aged, many thouſand Years old, and that many and manifold are the Alterations which Time hath made in ſeveral Parts and Quarters of the World; to the Notice and Diſcovery whereof no written Record, or unwritten Tradition at this Day, can reach or direct us: Tradition it ſelf (longer liv'd many Times than any written Evidence) failing us for Age. Of ſuch a Nature they

they conceive may this of the *Æſtuary* be, ſo very ancient, as Time hath quite worn out the Memory of it; and that the Reaſon of the Sea's Receſs here, with an abſolute Valediction to the Place of its wonted Reſort, was its breaking, burſting, and cleaving aſunder, that *Iſthmus*, or Neck of Land, between *Gaul* and *Britain*, rendering the latter of the ſame Continent with the former: Such Things ('tis certain) have happen'd elſewhere. Thus (ſays *Seneca*) hath the Sea rent *Spain* from the Continent of *Africk*. Thus (as he adds) by *Deucalion*'s Flood was *Sicily* cut from *Italy*. More Inſtances of this Kind may be found in Mr. *Cambden*'s *Cantium*, and elſewhere. And although there be no certain Evidence of ſuch an Accident here, from ancient Hiſtorians or Geographers, yet is the Thing ſo ſtrongly and rationally argued, by him eſpecially, as by *Verſtegan* alſo, *Twine*, and others before him; and the Conjecture back'd with ſuch Plenty of probable *Criteria*, by the former, that I cannot but be of that Opinion; eſpecially, when to the plenty of Arguments muſter'd up by Mr. *Cambden*, I ſhall have contributed this one, by him and the reſt omitted; which is, that by a received conſtant Tradition, *Romney-Marſh*, that large and ſpacious Level, containing (ſaith Mr. *Cambden*) 14 Miles in length, and 8 in breadth, was ſometime Sea-Land, lying wholly under Salt-water. And if I may gueſs at the Time and Occaſion of both that, and our *Canterbury* Level's Recovery from the Sea, I ſhall be apt to pitch upon that of the Sea's breaking through, and in Time working and waſhing away that *Iſthmus* between us and *France*. And then, whereas beforetime *Romney* Level (which had and hath its *Stoures* too, or *Æſtuaria* as well as ours) and this other not improbably (no high Lands, as we ſee, interpoſing or impeding their Conjunction) were but one and the ſame Level, and lay under the Sea; now both the one and the other (the Sea having ſo much more Play and Elbow-room, than formerly, by cleaving aſunder the *Iſthmus*) were reſcued from it, and of an *Æſtuary* became ſuch a rich and noble Valley or Level, as is ſecond to none in *England*.

And if from hence any one ſhall take an Hint, to conſider of the *Netherlands* or *Low Countries*, and enquire whether thoſe in whole, or in part, may not have ariſen out of, and conjecturally aſſigned for our *Kentiſh* Lowlands, I ſhould not at all wonder at it.

As to the fourth Query, by what Means the Sea once having its Play there (at *Chartham*) this Creature comes to lie and be found ſo deep in the Ground, and under ſuch a ſhelving Bank? My Anſwer is, That ſuppoſing this with the reſt of the Level or Valley once occupied by the Sea, or Salt-water; that being a Creature which by Fluxes and Refluxes always is in Motion, and thereby in Time beating upon, and working it ſelf into the Bank, or riſing Ground there, might at length ſo far undermine, eat into, and looſen it, as to fetch down ſo much Mould or Earth upon, or over the Place, as to lodge the Creature at ſo great a Depth. Or elſe perhaps, the continual Agitation of the Water might in Time force, drive up, and caſt over it that great Quantity

tity of Ooſe, Earth, and other Matter, under which it lay. By the way, it is obſerved, that the Nature of the Soil here and there is ſuch, ſo looſe, ſupple, rotten and ſandy, that meerly of itſelf, it is apt to ſink and fall in; as was lately experienced by a Saw-pit digg'd hard by, which after a little Time, by the Earth's giving way on each Side of it, fell in, and fill'd up itſelf.

Fig. 26, 27. *Repreſent two of the* Teeth *above-mention'd.* Fig. 26, 27.

2.] Mr. *Somner* is of Opinion, (with Mr. *Cambden*, and other Antiquaries) That it is highly probable (if not abſolutely certain) That *France* and *England* (or *Gaul* and *Britany*) were anciently joyned by an *Iſthmus*, or Neck of Land, where now is the narrow Paſſage between *Dover* and *Calais*: Which, many Ages ſince, (beyond the reach of any Hiſtory now extant) was (by the Seas violently beaten upon it on both Sides) worn away, or broken through. Whereby, what was once an *Iſthmus*, is now become a *Fretum* or narrow Sea. — *on the ſame, by Dr.* J. Wallis, n. 275. p. 967.

Mr. *Cambden* in his *Britannia* (in that Chapter where he treats of *Kent*, or *Cantium*) gives us many cogent Arguments, which, if taken all together, ſeem to me a convincing Evidence, that there had once been ſuch a Conjunction; but not for many Ages now paſt.

To which I may add one more (of which Mr. *Cambden* takes no notice in this Place) from the *Unity of Language* between the ancient *Gauls* and *Britains*; and from the great Intercourſe between thoſe in *Gaul*, and the *Druides* in *Britany*; (of which ancient Writers take notice:) which is not likely to have been, if there had not been an eaſy Communication between the one and the other. Which, though it be not a *Phyſical* Argument (as are thoſe of Mr. *Cambden*) is a good *Moral* Inducement, in Confirmation of them.

To thoſe Arguments of Mr. *Cambden*, Mr. *Somner* adds another, *a Parcel of ſtrange and monſtrous Teeth and Bones*, which (in the Month of *September* 1688.) upon digging a Well in the Pariſh of *Chartham* (about three Miles Southward from *Canterbury*) in the Land of Mr. *John Somner*, were found at the Depth of *ſeventeen Foot under Ground*. Which *Bones* and *Teeth* (from the Figure and Greatneſs of them, and from the Condition of the Earth wherein they were found) he judgeth to have been the Remainders of ſome *Hippopotamus*, or other large *Marine* Animal, which (many Ages ſince) had periſhed there; which hath ſince been covered with this Depth of Earth.

This *Chartham* he obſerves to lye about the middle of a large rich Valley, for about twenty Miles or more in length, and of a conſiderable Breadth; having on each Side of it at a conſiderable Diſtance, a long Tract of Hills, or high Grounds. Through which Valley, there now runs the River *Sture*, *Stoure*, or *Eſture*, for twenty Miles or more, by *Aſhford*, *Wye*, *Godmerſham*, *Chilham*, *Chartham*, *Canterbury*, *Fordwich*, and ſo to *Sandwich*, where it diſcharges itſelf into the Sea.

This

This long and large Vale, (from the Situation of the Place, the Nature of the Soil, and the Remains of this Marine Animal, lodged here at ſo great a Depth under Ground) he judgeth to have been (in former Ages) an *Æſtuarium*, or Arm of the Sea, into which the Sea, (being ſtopped by the *Iſthmus*, which then joyned *France* and *England*, from the Courſe which now it takes) did diſcharge itſelf; which, in Proceſs of Time, being filled up, (partly by the Earth, Sand, Ooſe or other Matter brought in by the Sea, and lodged there; partly by the Earth waſhed down, or falling upon it from the Hills on both Sides;) is reduced to the State we now ſee.

Let us then conſider, what muſt have been, if this Hypotheſis be true; and how it agrees with what we ſee.

Firſt, If ſuch an *Iſthmus* had once been, where now is the Paſs between *Dover* and *Calais*, the great Seas on both Sides muſt continually beat upon it with a fierce impetuous Tide, twice in four and twenty Hours. The Northern Sea between us and *Holland* (called *Oceanus Germanicus*) on the Eaſtern Side; And the Weſtern Sea between Us and *France* (called *Oceanus Britannicus*) on the Weſtern Side. Which (in Proceſs of Time) may well be ſuppoſed likely enough to wear away, or break through a narrow *Iſthmus*.

The Weſtern Tide coming in fiercely between Us and *France*, fretting on the Coaſt on both Sides, muſt needs be ſuppoſed to bring with it a great deal of Earth, Sand, or Mud. But, being ſtopped in its Current by this *Iſthmus*, did not depoſit it (as might be thought) on the Side of it, (which might ſtrengthen it) but found an Opportunity of diſcharging itſelf on the ſpacious Level of *Romney Marſh*; (which, as *Cambden* tells us, is *fourteen Miles in length, and eight in breadth*;) fretting that *Iſthmus* as it comes along; and then (at ſtanding Water, about the Tide's Receſs) letting it fall on that Level, and lodging it there: But then again, fretting that *Iſthmus*, and the Coaſt all along, as the Tide returns, with a like Force as it came in. Which gives us a fair Account, both how that *Iſthmus* might be waſhed away, and how that Level might be raiſed to that height it now is. For no Man can doubt (who doth well know the Situation of the Place, and the Nature of the Soil) but that all that Level had heretofore been Sea. And, even at this Day, it lies ſo much lower than the Surface of the Sea at High-Water, that it would (much of it) be overflowed every Tide, if not defended (at a vaſt Charge) by *Dim-church* Wall, for many Miles together.

Whether it had a like Opportunity of ſuch an Indraught (and in what Proportion) on the *French* Coaſt, I cannot tell. But, that this is the Condition of *Romney-Marſh*, no Man doubts.

The *Northern* Sea (between us and *Holland*) muſt, in like Manner, have beat on the Eaſt Side of that *Iſthmus* with a like impetuous Tide, twice in four and twenty Hours. But, being there ſtopped in its Courſe, would have the like Opportunity of diſcharging itſelf on the Coaſt of *Holland*,

Holland, (as the Weſtern Sea on *Romney-Marſh.*) Whence it is, that *Holland* and *Zealand*, which (by the Conſent of all) is judged to have been once Sea, is now raiſed thirty or forty Foot higher than it had once been.

And the ſame *Northern* Sea, which (on this Account) hath ſo large an Inlet (Eaſtward) on the Coaſt of *Holland*; would (Weſtward) inſinuate itſelf likewiſe on the *Engliſh* Coaſt, where-ever it might find low Grounds. Which is the Caſe of this large Valley, where now runs the River *Sture*, *Stoure* or *Eſture*; (which Name it is ſuppoſed to have taken from the Corruption of *Æſtuarium:*) for more than twenty Miles; (and nothing appears why we ſhould not think it had ſo done;) entering at the low Grounds near *Sandwich* (cloſe by that *Iſthmus*) and running up that Level (by *Canterbury*, *Chartham*, *Chilham*, and ſo forth) as far as *Aſhford*, or farther, which Valley had once been much deeper than now it is. For, it ſeems, that even at *Chartham* (which is now twelve Miles from the Sea) the Ground is raiſed at leaſt ſeventeen Feet; and the Soil, at that Depth, found to be of a like Condition, as where the Sea is known to have been; and nearer to the Sea, it may well be preſumed to have been yet deeper. Which is confirmed by the Reliques of this Marine Animal there found; and by Anchors, and Shells of Fiſhes, found elſewhere in the Borders of this Valley, at a great Depth under Ground.

Now, that the Sea may thus raiſe the Ground on ſuch In-draughts, by Sand, Earth and Mud, brought in and lodged there at every Tide, is not at all unlikely: For we ſee the ſame at this Day. Particularly, in the Iſle of *Oxney* (near adjoining to *Romney-Marſh*) there was a low Level, oft in Danger of being overflowed by the River *Rother:* But, ſomewhat more than threeſcore Years ago, the Sea being let in, hath raiſed that Level very conſiderably; by bringing in, and lodging there a conſiderable deal of Earth and Mud every Tide: But withal, it hath ſo fretted the Channel, by which it enters and goes out again, that the Channel by *Rye*, which (within my Memory) was ſo ſhallow near what was call'd *Kent*-Bridge, that Men were wont to ride through it; but now (by the Tide's entering and returning) that Bridge is long ſince ſwallowed up, and the Channel become ſo broad and deep, that a Veſſel of good Burden might ride there at Anchor. A fit Reſemblance of the Sea's fretting this *Iſthmus*, and filling up the *Æſtuaries* on both Sides of it.

The like, in good Meaſure, is to be ſeen at (what they call) the *Dogger Sands*, which is a Bank of Sands lying (obliquely) from about the Coaſt of *Norfolk* toward the Coaſt of *Zealand*, or North-part of *Holland*, which is the Place where the Northern and Weſtern Tides (ſince the Rupture of the *Iſthmus*) do now meet; and do there (at ſtill Water, for about half an Hour or more, or at the turning of the Tide) depoſit the Mud and Sand, which (by their rapid Motion) is both Ways brought thither. Which is ſuppoſed to be the true Cauſe of

that ſandy Bank. Whether this in Tract of Time may there form a new *Iſthmus*, (if the World laſt long enough) I cannot ſay; but I am apt to think that the former *Iſthmus*, if the Tides had ſtopped there, and had not found thoſe In-draughts, on which to lodge what it waſhed from thence, might have continu'd, and been more ſtrengthen'd, by what (upon the Return of the Tide) would daily be lodged there.

And upon this Account (I think) it is, that the *Iſthmus* at *Corinth*, though beat upon by the two Seas (which give it the Name of *Bimaris Corinthus*) is not thereby deſtroyed: becauſe there are not ſuch Tides to waſh it away, nor ſuch In-draughts, on which to lodge what ſhould be waſhed from thence.

But the Caſe is much otherwiſe with this *Iſthmus* of ours; where are all Things to countenance this Hypotheſis. The ſteep Clifts at *Dover*, and thoſe at *Calais*, anſwering directly the one to the other; and appearing to View, as if that between them had been violently torn away. And the Sea between them (even at this Day) being much ſhallower at that Place than on either Side of it (as *Cambden* doth well obſerve) which are ſtrong Preſumptions, that there had been formerly ſuch a Conjunction.

The greateſt Doubt in this Caſe is, that there is no Hiſtory extant, which takes notice of ſuch an *Iſthmus*, or ſuch a *Rupture*, in this Place, which being a Thing remarkable, might have been thought worthy to be reported.

Which yet need not be thought very ſtrange, conſidering that we have no particular Account of the *Britiſh* Coaſt (which might determine this Queſtion) older than the *Romans* Acceſs hither with *Julius Cæſar:* Whereas this might have happen'd many Hundred of Years before that Time, when though the Iſland might be known, yet not the particular Coaſtings of it to the *Greeks* or *Latins*.

But I have this farther to ſay, *Plato* tells us a Story (as of a Thing which happened ſome Ages before his Time, and which at that Time was in a Manner generally forgotten) of an Iſland ſomewhere in the *Atlantick* Ocean, which by a Deluge and Earthquake (in the Space of a Night and a Day) was deſtroyed and ſwallowed up by the Sea; whereby that Sea (formerly navigable) was for ſome Time become unnavigable or unſafe, by Reaſon of the Mud and Reliques of that abſorbed Iſland. The Words of *Plato* (as tranſlated in *Henry Stephens*'s Edition, p. 25.) run thus; *Poſt autem, quum diluviorum & terræ motuum intemperies extitiſſet, unius noctis & diei ſpatio, omne illud bellicoſorum hominum genus in terram abſorptum fuit, illaque etiam Atlantica Inſula* (Ἀτλαντὶς νῆσος) *Maris fluctibus plane obvoluta diſparuit, unde & illud mare trajectu difficile eſt, quum lutum adhuc copioſum Inſulæ iſtius remanſerit.*

Which ſeems to me very applicable to the Rupture of this *Iſthmus:* Whereby this Iſland was not indeed wholly deſtroyed, but was broken off from the Continent, to which it was before united. And, upon

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ſuch an Accident, the Sea muſt needs be diſturbed, and put out of its Courſe, and render'd unſafe for Paſſage, before it came again to be ſettled. For though the firſt Breach might be made in the Space of one Night and Day, we cannot ſuppoſe the whole Bulk of it, when once broken, was preſently carried ſmooth away; but firſt the Top or upper Part of it (in a Day and Night's Time) and afterwards the lower Parts of it by Degrees. Which would render that Sea, if not quite unpaſſable, at leaſt troubleſome and unſafe.

And if in ſome Circumſtance this Narration chance to differ from the Matter of Fact, as calling the *Rupture* of this *Iſthmus* the *Subverſion* of an *Iſland*, this muſt be allowed in the Narrative of an old Tradition from Hand to Hand: For as ſuch it is there brought in.

For *Plato* doth there introduce *Critias* (then an ancient Man) telling a Story, which (when a Boy of ten Years old) he had heard from his Grandfather (who was ninety Years of Age) of what *Solon* (long ſince dead) had told him; namely, that an *Ægyptian* Prieſt had (long before) told *Solon*, that it did appear from ſome old *Ægyptian* Records (of which the *Greeks* had no Knowledge) that ſuch a Thing had happen'd in an Age ſo long before, as in compariſon of which *the Greeks were but as Children.* And all this Tradition (through ſo many Hands, and at ſuch great Intervals of Time) is, at every Step, reported from the Relator's preſent Memory. And 'tis very poſſible, that ſome one or other of theſe Relators might ſo far miſtake, or miſremember, as to call that a *Diſſolution* or *Diſappearance* of an Iſland (ἠφανίσθη) which was but a *Tearing it from the Continent.*

It ſerves, however, to the preſent Purpoſe, if at leaſt ſo much of the Story be true, *That long before* Plato's *Time, there had been ſome ſuch Diſſolution or Rupture of an Iſle or Iſthmus, ſomewhere in the* Atlantick *Ocean,* (that is, in the Northern Sea) *of which there were ſome Symptoms yet remaining in* Plato's *Time.* For, this being admitted, it is as applicable to the preſent Caſe (as to any we know) of which there are ſo many Symptoms yet remaining to this Day.

I know that *Rudbeck* in his *Atlantica*, Cap. 7. Sect. 8. pag. 293. doth endeavour (in Favour of his *Sueonia*) to put an allegorical Senſe upon this whole Paſſage.

But I ſee not why it may not be underſtood in a plain literal Senſe, as a true Matter of Fact, (though perhaps a little diſguiſed, as was wont to be the Faſhion in that Age in relating old Stories) and is very conſiſtent with all that *Rudbeck* cites out of *Plato*, in that whole ſeventh Chapter of his *Atlantica.*

For the Name of the *Atlantick Sea* (wherein this Iſland is ſaid to be) was not then (nor is now) confined to the Coaſt of *Sweden*, but extended as far as the *Britiſh* Iſland, and much farther. And when *Rudbeck* tells us out of *Plato*, that the whole *Atlantica* was as big as *Libya* and *Aſia* (which whether meant of *either of them* ſingly, as *Rudbeck* underſtands it, or of *both together*, as the Words ſeem to import, ἅμα λιβύης

λιβύας καὶ Ἀσίας μείζων, I will not contend; we cannot ſuppoſe it to be *Plato*'s Meaning, that this *whole Region* was ſwallowed up; but rather ſome ſmall Part of it, from whence perhaps the whole might take its Denomination. And though he tells us from another Writer, that it was *five Days Voyage* from the *Britiſh* Iſland, to (that part of) his *Atlantica*, where for *thirty Days together the Sun doth not ſet*; this hinders not, but that the *Britiſh* Iſlands may be part of the *Atlantick Region*, though ſo far diſtant from the utmoſt Northern Cape of it.

I know not whether I may not yet venture farther: This Author tells us, that this *Æſtuary* (from *Sandwich* to *Aſhford*) might perhaps flow ſo much farther, as to meet with that *Æſtuary* on *Romney-marſh*, and (both being conjoin'd) become *one Level*.

There is, I think, about three or four Miles diſtance between *Aſhford* and the neareſt part of *Romney-marſh*: How the intermediate Lands be qualified, I do not well remember.

But if this be admitted, that the two *Æſtuaries* (that of *Stoure*, and that of *Romney-marſh*) in former Times may thus have met; this opens a new Scheme, of which before we were not aware. For then we muſt ſay, that the two Tides (that from the North and that from the Weſt) which now meet at the *Dogger Sands*, did then meet at the Confluence of theſe two *Æſtuaries*: And then (as was ſaid of the *Dogger Sands*) bringing (on both Sides) Earth, Mud, and Sand, to this Place, and lodging it there, might firſt form an *Iſthmus* there, and (by Degrees) fill up thoſe *Æſtuaries* on both Sides: In the mean while, waſhing away that *Iſthmus* between *Dover* and *Calais*, and opening a new Paſſage as now it is.

There be many other *Æſtuaries* in *England*, where the Sea now enters a great Way into the Land; and how far it might have entered farther in former Times, who can tell? As that Sea by *Briſtol* between *Wales* and *Cornwall*: That of the *Humber* between *Yorkſhire* and *Lincolnſhire*: And we may reaſonably think, that the *Waſhes* and the *Fens* in *Lincolnſhire*, may have heretofore been Sea, or overflowed by the Sea at high Tides: And that of the *Thames* (between *Kent* and *Eſſex*;) which now flows (above *London* and *Brentford*) within a Mile of *Kingſton* (at Spring-Tides;) it may perhaps ſeem too daring, to think it may formerly have flowed as far as *Oxford* (between *Shot-over* Hill and *Foxcomb* Hill) and ſo onward toward *Wallingford* (in the *Romans* Time called *Galena*) but there is this to countenance it, that (if I be not much miſinformed) there be frequently found (in our Stone-Quarries and Gravel-pits) about *Oxford*, Fiſh-ſhells, and even the Bodies of Fiſh petrified, at great Depths under Ground. And there have been (no doubt) and now are (in *England*) many other *Æſtuaries*, Creeks, or Arms of the Sea (entering a great Way within Land) ſome whereof may be in a Manner filled up, and become firm Land; others much narrower, ſhallower and ſhorter, than in former Times they have been. For it is the Nature of *Æſtuaries*, where the Tides flow in, to leave behind

behind them, at their Return, much of Mud, Ooſe, or Sleech, as they call it, which doth in Time come to be firm Land.

3.] At *Hythe* in *Kent* (which is one of the *Cinque Ports*) there was (in our Fathers Time) a convenient Harbour for ſmall Veſſels, which is now ſwarved up; ſeveral Attempts have been made to recover the Harbour, but with ſmall Succeſs. For when (with great Labour and Charge) they have (in ſome Meaſure) opened it, it hath ſoon been filled up again, by what the Sea caſts up. And whoever conſiders the vaſt Quantity of (what they call) *Beach*; that is, a vaſt Multitude of ſmall looſe Stones and Fiſh-ſhells, caſt up by the Sea at *Hythe*, *Lyd*, and elſewhere, on the Coaſt of *Romney-marſh*, (for divers Miles in Length and Breadth, and to a great Depth) will not think it ſtrange, that a *Creek* or *Æſtuary* ſhould come in Time to be filled up, and become firm Land. And in many Places of this *Beachy* Ground, where (within the Memory of Perſons now living) nothing was to be ſeen, but ſuch looſe Stones and Shells (to a great Depth) it comes (by Degrees) to be covered with Earth, and becomes Paſture Ground. —*on the* ſame, *by the* ſame, *ibid.* p. 978.

On the contrary, that what was formerly Firm-land, may be ſo deſtroyed or waſhed away, as to become Sea, is evident from (what they call) the *Goodwin-Sands*, on the Coaſt of *Kent*, which is ſaid to have been the Lands of Earl *Goodwin*, but loſt by an Inundation about the Time that *Tenterden* Steeple was built, (which gave Occaſion to that Ironical Proverb of Things Cotemporary, that *Tenterden Steeple was the Cauſe of* Goodwin *Sands*.) The Occaſion of ſuch different Effects, depending on the different Situation of the Shores, and the ſetting of the Tydes; ſo as to waſh off from one Place what it lodgeth on another.

And many ſuch Alterations (no doubt) have been of the Face of the Earth, all the World over, of which we have no particular Hiſtories. For the World was of a great Age, before the writing of any Hiſtories (except the Bible) now extant.

And who knows, but that in former Ages, even amidſt the *Alps*, there may have been large *Lakes*, which, in proceſs of Time, (by Earthquakes or other Accidents) may have been drain'd of their Water, and become fruitful Valleys: Of which it is ſaid, divers Symptoms have been diſcover'd, even amidſt the *Alps*, in later Ages.

And ſomething of the like Nature hath happen'd within ſome few Years laſt paſt, in *Jamaica*, in *Sicily*, and other Places.

4.] Since I wrote laſt on the Subject of the *Iſthmus*, &c. I find Mr. *Luffkin* † has informed us of divers Bones of an extraordinary Bigneſs, found lately in a Gravel Pit, not far from *Harwich* in *Eſſex* (much like thoſe found at *Chartham* in *Kent*,) at a great Depth under Ground, which Bones he thinks rather to have been the Bones of an Elephant, than of an *Hippopotamos*, or other Marine Animal. —*on the* ſame, *by the* ſame. n. 276. p. 1030. † *Vid.* infra, S. X.

But

But which ever it is, it will equally prove thoſe Valleys to have been much deeper in former Times, than now.

I obſerve, that the River in *Eſſex*, and that in *Kent*, near which the Bones were found, are both of them named the *Stowr*; which, whether it be a Corruption of the *Latin Æſtuarium* (as Mr. *Somner* conjectures) or of the *Britiſh ys-dwr*, (that is, *the Water*) I will not diſpute.

And that the Bones were found (in both Places) much at the *ſame Depth*, (about 16 or 17 Foot under the Surface of the Earth) which therefore may (probably) have been lodged (in both Places) much about the ſame Time: And perhaps, when the Emperor *Claudius* brought his *Elephants* into *Kent* and *Eſſex*; as Mr. *Luffkin* intimates out of *Dion Caſſius*.

I obſerve alſo, that thoſe petrified Bones, in both Places, were found in *gravelly Grounds*, (as are thoſe petrified Shells, and Bodies of Fiſhes, in Gravel Pits and Stone-Quarries near *Oxford*). How far the Steams, Fumes, or Fluors of the Earth, which contribute to the Formation of Stone or Gravel, may conduce to the petrifying of theſe Bones, Shells, or other Bodies; I leave to the Conſideration of the Naturaliſts.

And whether the Impregnation of ſuch *Steams*, may not *Swell* ſuch petrified Bodies, to a larger Proportion than before they had. Like as we obſerve Wood (and other like Materials) in a moiſt Air to Swell; by the Diſtention of their Pores, upon the Intromiſſion of moiſt Particles. For I take all Petrifications to be made, either by *Incruſtation* or *Intromiſſion* of ſtony Particles.

And I well remember, that (many Years ago) at *Moldaſh* in *Kent*, (not far from *Feverſham*) on ſome high Grounds, and very ſtony, (which uſed to be ſometimes Paſture, and ſometimes plow'd) I have obſerved divers *Oyſter-ſhells* (petrified, or partly ſo) much larger and thicker, than the ordinary Proportion of Oyſters in thoſe Parts, and very weighty; which Oyſter-Shells might have been purpoſely thrown there long before, as being reputed a good Manure for Land; and might have been there impregnated with like *Halitus*, *Effluvia*, as are the numerous Stones on thoſe Lands.

I have known the Inhabitants, heretofore, have uſed to cauſe the Stones, in thoſe Lands (becauſe they are very numerous) to be gather'd up, and carried off the Lands by Cart-loads, to make more Room for the Graſs to grow. But of later Years, they forbear (I have been told) ſo to do, as thinking the Warmth (or ſomewhat equivalent) of thoſe Stones, is rather an Help, than Hindrance of the Earth's Fertility.

But (to return to what I was ſpeaking of) I ſee not why we may not think the *Stowr* in *Eſſex*, and the *Stowr* in *Kent*, to have been (both of them) *Æſtuaries* of the *Northern Tyde*; before the Rupture of that *Iſthmus* between *Dover* and *Calais*: (And the like of the River near

near *Malden*, and other ſmall Creeks on the Coaſt.) Though not ſo great as thoſe of *Humber* and the *Thames:* which were then *Æſtuaries* of the ſame Sea; as are many others on the Coaſt of *Scotland*.

I ſay, *before that Rupture*; For, ſince that Rupture, the Caſe (as to the *Thames*) is ſomewhat altered. For the Weſtern Tyde (between us and *France*) which was then ſtopped at this *Iſthmus*, doth now flow on (through that *Fretum*) beyond the Mouth of the *Thames*, as high as the *Dogger-ſands*; which doth therefore ſupply the *Æſtuary* of the *Thames*, which was formerly furniſhed from the Northern Sea.

And theſe ſmaller *Æſtuaries* might ſooner be ſwarved up by what every Tide lodgeth there, while, thoſe greater *Æſtuaries*, are but ſhortned, and become narrower, than they had formerly been.

And as to the *Thames* in particular; it ſeems very evident, (if we conſider their Situation, and the Nature of their Soil, that much of the Low Grounds (in *Kent* and *Eſſex*) on both Sides of the Mouth of the *Thames* (adjacent to the Sea,) had formerly been Sea, (as well as that of *Romney-marſh.*) And when the Mouth of the *Thames* was ſo much wider, no doubt but it flowed much farther than now it doth. And how far, who can tell?

It may perhaps be objected, that the ſmall Rivers now remaining, in the Bottom of theſe Valleys, which may have been ſuppoſed (in former Times) to have been *Æſtuaries*; do now run more wriggling (with more Turnings and Windings) than do theſe Valleys. But this need not at all ſeem ſtrange, when as we may daily ſee the ſame, in the Bottom of a muddy Ditch (or Water-courſe) when the Water is almoſt drained off, the Mud yet remaining ſoft: the little Water, yet remaining, will work out of itſelf (amidſt the Mud) a wriggling Paſſage (according as the Mud will more or leſs give way) much more crooked, than was ſuch Ditch when full of Water, and the like muſt needs happen in the gradual Draining of ſuch *Æſtuaries*, according as the ſoft Earth will permit. Which Crookedneſs will continue, when the Banks on both Sides do (by Degrees) grow firmer.

As to what I ſaid concerning the Iſle of *Oxney*; A low Level in that Iſle, which had for divers Years lain under Water, is now raiſed by intromitting the Tide, to a conſiderable Height above what it had formerly been; and the Channel from thence to *Rye*, is (by the Tide's paſſing in and out) become much wider and deeper than heretofore. Both which are evident, and not to be denied.

If we look in the more ancient Maps of *Kent* (older than the Year 1640) we will find, that what we call the *Iſle of Oxney*, was then but a *Peninſula*; being (by a ſmall *Iſthmus* or Neck of Land at the North-Eaſt Corner of it) continued to the reſt of the Countrey: And the Tide from *Rye* to that Place (which now flows ſtraight onward on the North Side of the Iſle) was there ſtopped by that *Iſthmus*, and did wheel

wheel about on the South Side of it: Or rather, the River *Rother*, did (from the North Side of the Iſland) wheel about by the South Side (to that Eaſtern Corner) and thence (by the Channel) to *Rye*.

While Things were in this ſtate; divers Mooriſh or Marſh-lands, adjoining to the River *Rother*, were oft in Danger (upon great Rains) to be drowned. But ſo it once happened (by what Accident I know not) that this drowned Land had unexpectedly (in a Night's Time, or little more) diſcharged itſelf on another Level, ſomewhat lower than itſelf.

Upon which Indication, it was thought adviſeable (by cutting that *Iſthmus*) to allow thoſe Waters on the North Side of the Iſland a ſtraighter Paſſage towards *Rye*; and to let thoſe lower Grounds for ſome Time to lye under Water (paying the Rent of them) till ſuch Time as (by intromitting the Tide) they might be ſomewhat heightned, and then timely recover'd. In Order to which, Commiſſioners of Sewers have ever ſince from Time to Time been iſſued out for that Purpoſe; and the Work in a good Meaſure effected, though not finiſh'd.

An Account of Large Teeth *dug up in* Ireland, *by Mr.* F. Neville. n. 346. p. 367.

IX. 1.] Four large Teeth were lately found in the North of *Ireland*, about eight Miles from *Belturbet*, at a Place call'd *Maghery*, in Part of the Biſhop of *Killmore*'s Lands, ſinking the Foundation for a Mill near the Side of a ſmall Brook, that parts the Counties of *Cavan* and *Monoghan*.

Two of them are of a larger and two of a ſmaller Sort; the largeſt is the fartheſt Tooth in the under Jaw, the other is like it, and belongs to the oppoſite Side; the leſſer Tooth I take to be the third or fourth Tooth from it, and has its fellow: Theſe are all that were found, and one of them in a Piece of the Jaw-bone, which fell to Dirt as ſoon as taken out of the Earth; there was Part of the Scull found alſo of a very large Size and Thickneſs, but as ſoon as expoſed to the Air, that mouldered away as the Jaw had done.

The Account I had, led me laſt Week to the Place where I was reſolved to make the niceſt Search I could; but the Water-wall of the Mill being built, and the Ground all incumbered with the Earth, that was thrown up, I could have little Opportunity of doing any Thing but to enquire of the Workmen the Manner of finding the Teeth, and where and how they lay. There were ſome few Pieces of Bones found, but none entire, yet by thoſe Bits that were found, one might gueſs that they were Parts of thoſe that were of a larger Size.

The Place where this Monſter lay was thus prepared; which makes me believe it had been buried, or that it had laid there ſince the Deluge. It was about four Foot under Ground, with a little Riſing above the Superficies of the Earth, which was a Plain under the Foot of a Hill, and about 30 Yards from the Brook or thereabout. The Bed whereon it lay, had been laid with Fern, with that Sort of Ruſhes here called *Sprits*,

Sprits, and with Buſhes intermixed. Under this was a ſtiff blue Clay, on which the Teeth and Bones were found: Above this was firſt a Mixture of yellow Clay and Sand, much of the ſame Colour; under that a fine white ſandy Clay, which was next to the Bed: The Bed was for the moſt Part a Foot thick, and in ſome Places thicker, with a Moiſture clear through it; it lay ſad and cloſe, and cut much like Turf, and would divide into Flakes, thicker or thinner as you would; and in every Layer the Seed of the Ruſhes was as freſh, as if new pulled, ſo that it was in the Height of Seed-time, that thoſe Bones were laid there. The Branches of the Fern, in every Lay as we opened them, were very diſtinguiſhable, as were the Seeds of the Ruſhes and the Tops of Boughs. The whole Matter ſmelt very ſour, as it was dug, and tracing it I found it 34 Feet long, and about 20 or 22 Feet broad.

It will be well worth Conſideration, what ſort of a Creature this might be, whether Human or Animal; if Human, there was ſome Reaſon for the Interment, and for that Preparation of the Bed it was laid on; if Animal, it was not worth the Trouble; if Human, it muſt be larger than any Giant we read of; if Animal, it could be no other than an Elephant, and we do not find, that thoſe Creatures were ever the Product of this Climate. And conſidering, how long this muſt have laid here, I do not believe the Inhabitants then had any Curioſity or Conveniency to bring ſuch into this Kingdom; for I ſuppoſe the beſt of their Ships could not carry one. Then if an Elephant, or ſome other Beaſt which muſt have Proportion to the Teeth, it muſt have laid there ever ſince the Flood; and if ſo, then the Bed, on which it lay, muſt be of its own making: Whence it will follow, that the Flood coming on him, while he lay in his Den, he was there drown'd, and covered with Slime or Mud, which ſince is turn'd into the Subſtance of the Earth before-mention'd. There were alſo a great many Nutſhels found about the Bed, perhaps thoſe might have been on the Buſhes, which compoſed Part of the Bed.

The two large Teeth are of equal Weight, two Pound three Quarters each: The two little Teeth are ſix Ounces each; but there are ſome of them waſted, and ſome of the Holders that go into the Jaw broken off.

2.] The *Four Teeth*, with ſome of the Fragments of the Bones that were found with them, have been brought to *Dublin*, where I have examin'd them particularly, and taken the following correct Sketches.

I am fully convinced, that they muſt certainly have been the *Four Grinding Teeth* in the lower Jaw of an *Elephant*: And that the many looſe Fragments of thoſe large Bones, that were found with them, muſt have been Remains of the ſame *Animal*.

— Remarks *on them by Dr.* T. Molyneux. *ibid.* p. 370.

Fig. 28. *Fig.* 28. *A A* is the larger Grinder of the under Jaw on the right Side, weighing two Pounds and three Quarters of a Pound.

b, b, b, b, b, b, b, are white, rough, indented Borders, ſeven in Number, of an irregular Shape, ariſing about the tenth of an Inch higher than the hard black ſhining Surface of the Tooth; this rough raiſed Work ſerves for the bruiſing and grinding the *Animal's* Food, the tough Grains of Rice, Leaves, Fruits, and the Boughs of Trees, and is made of ſo extreme an hard Texture, that it reſembles large knotted Threads of white *Glaſs*, laid on and cloſely faſtned to the dark Superficies of the *Tooth:* And anſwers that glaſſy Surface wherewith Nature has armed the Outſide of the *Teeth* of moſt *Animals*, to prevent their wearing from the conſtant Attrition in Chewing of their Foods.

c, c, c, c, c, is that Part of the Tooth which riſes above the Gums, and continues even now diſtinguiſh'd from the reſt of the Bone, by having its Colour of a different Shade.

d, d, d, d, d, d, d, are many ſtrong Tangs or Roots, ſeemingly united all together, by which the Tooth received its Senſe and Nouriſhment, and though it was ſo large and ponderous, by theſe it kept firmly fixt into the Jaw.

For the Mechaniſm Nature ſhews itſelf to have followed in framing the *Teeth* of this *Animal*, is no more than this: Whereas in other Creatures, ſhe has divided that bony Subſtance wherewith they chew their Food, each having its peculiar Roots to ſecure its Articulation in the Jaw-bone; ſhe has in this of ſo great Bulk, for the greater Strength, Stabiliment, and Duration of its *Teeth*, and the better to provide for a compleat Attrition of the Aliment, in order to perfect the Digeſtion ſo thoroughly, as to ſuſtain the Life of the Animal for two or three hundred Years, (as it is a common received Opinion in the *Eaſt*) ſhe has, I ſay, contrived to make the Subſtance of the *Teeth* in their Roots below, and in their upper Parts above the Gums, cloſely unite together; and coaleſcing thus, form a few large maſſy Teeth inſtead of many ſmall ones.

As for Inſtance, in *Man's Body*, that is of ſo much a leſs Size, the Number of the Teeth, (when the whole Sett is compleat) reckons to thirty-two; whereas in the large *Elephant*, the Teeth of both the Jaws amount in all but to Eight, beſides its two great Tuſks, which rather ſerve as Horns for its Defence, than Teeth to prepare its Food; and therefore I think not ſo very properly call'd Teeth.

Fig. 29. *Fig.* 29. *E, E,* is the ſmaller *Grinding Tooth* of the under Jaw on the ſame Side; its Surface covered over with the ſame white indented Work, as before deſcribed for grinding of the Food.

f, f, f, are three large Roots, that kept it firmly fixed in the Jaw-Bone.

This ſmaller Tooth weighed full ſix Ounces.

Fig.

Fig. 30. *G*, *G*, is the large *Grinder* of the under Jaw on the left Side, much of the Size, and Shape, and Weight, with its fellow Tooth, deſcribed *Figure* 28. It ſhews its Roots and all its Parts, with the rough protuberant white Work on its upper Surface made after the ſame Contrivance, and formed after the ſame ſtrong Model as the former. Fig. 30.

And truly if one conſiders it, 'tis plain, that were not the *Teeth* of this Creature made of ſo large a Size, and withal of ſo maſſy and firm a Subſtance, 'twere abſolutely impoſſible they could reſiſt the Force, and bear all that Preſſure, wherewith thoſe vaſt Muſcles exert themſelves, that move the lower Jaw in Maſtication, in this ſo ſtrong an Animal.

Fig. 31. *H*, *H*, is the ſmaller *Grinding-Tooth* of the under Jaw on the ſame Side; it is leſs compleat than the ſmall Tooth deſcrib'd before in *Fig.* 29. for ſome of the Root is wanting, and Part of its outward grinding Surface is broke off at *k*, *k*, ſo that it weighs ſomewhat leſs; yet what remains, exactly ſhews the ſame kind of Work and Shape of the other Tooth, that anſwer'd it on the right Side. Fig. 31.

Theſe *Four Teeth* here deſcrib'd, fully compleat the Set of the Teeth, wherewith Nature has furniſhed the lower Jaw of the *Elephant*; and are anſwered by juſt as many more, formed after the ſame Manner in the upper Jaw, as Dr. *Moulins* informs us, who diſſected the *Elephant* that was burnt at *Dublin* in 1681. In its Anatomy, *p.* 40. ſpeaking of the Teeth, he aſſures, there were beſides the Tuſks, only four Teeth in each Jaw, two in every Side; and that theſe eight Teeth were all *Molares*, ſo that he had no *Inciſores*.

But notwithſtanding this, perhaps it will be ſaid, we may not haſtily conclude from hence, that our *Great Teeth* dug up in *Ireland*, muſt certainly have been the *Four Grinders* of an *Elephant*, ſince they might as well belong to ſome other large kind of *Terreſtrial* or *Marine Animal*. As for the Hint of their being *human* or *gigantick*, 'tis ſo groundleſs a Thought, and ſo contradictory to *comparative Anatomy*, and all *Natural Hiſtory*, it does not deſerve our Conſideration.

To obviate this, I take Notice firſt in general, that the differing Kinds of living Creatures, wherewith Nature has ſtock'd the World, are not more diſtinguiſhed by the Make of any Part of their Bodies from one another, than by the various Shape and Diſpoſition of their *Teeth*: And hence it is, we ſhall not find any two diſtinct *Claſſes* of *Animals*, that do exactly agree in the ſame Make and Ranging of their Teeth.

But to be more particular, I ſhall here ſet down at length, the Words of two late Authors, that purpoſely have deſcribed the *Teeth* of the *Elephant*.

Dr. *Blair*, in his Deſcription of the Teeth of this *Animal*, ſays, *Dr.* Moulins *well obſerves, that they are all* Molares, *being two Inches broad in that Part of them wherewith they grind, and ſix Inches and a half* *Vid.* Infra, V. v. p. 117.

long on the Right Side, and five Inches and a half on the Left. Their Surface, though flat, is yet very unequal, for they have alternately placed, running from the Right to the Left Side, an Hollowneſs and then an Eminence; and this Eminence is ſurrounded by a rough protuberant Border. There are nine of theſe Hollowneſſes, and as many Eminences, undulated as they paint Sea Waves.

'Tis remarkable, how very exactly all this agrees with our Figures: 'tis true, thoſe *Hollowneſſes* and *Eminences*, which he mentions to be *nine*, do not ſo nicely hit with the Number of thoſe in our *Teeth*: but this Difference proceeds from hence, that he deſcribes here the Grinders of the upper, whereas ours are the *Teeth* of the lower Jaw; though ſuch a Diſtinction as this, I am apt to think, may very well ariſe even in thoſe of the ſame Jaw, in various Animals, from ſome peculiar Diſpoſition in one from another, nay, and perhaps in the ſame Animal, at differing Times, according as it happens to be older or younger.

A little farther * where he gives an Account of thoſe of the under Jaw, he ſays,

* *Vid.* infra. V. v. p. 121.

The hind Tooth of the Right Side is four Inches, and that on the Left five; the one half of their Surface, where they begin to appear above the Gums, is ſemicircular, with the foremention'd Ridges and Sulci *running tranſverſly, four on the Right Side, and five on the Left; the other half* (or Tooth I ſuppoſe he means) *has five of theſe Eminences where it grinds on the Right, and four on the Left: Each of the four Teeth is ſix Inches long, and has ſix or ſeven of the foremention'd Eminences, and as many Depreſſions: Theſe Teeth are the moſt firm, ſolid, and weighty Bones, of any Animal yet known.*

Mr. *Ray* in his *Synopſis Animalium Quadrupedum*, when he comes to give us the Deſcription of the *Elephant*, has the following Words: *Os pro mole Belluæ parvum, quatuor in utrâque maxillâ Dentibus molaribus ſeu Dentium molarium Maſſis inſtructum*; *ſiquidem* plurimi Dentes in Os ſolidum & durum *ita infixi ſunt, ut cum eo & inter ſe* unum & continuum Corpus *efficiant. Dentes hi lineas parallelas undulatas octo vel novem in ſuperficie maſſæ efficiunt*; *ſuntque reliquo oſſe* candidiores: *Maſſæ integræ, Dentium ſingularium modo, per Gomphoſin maxillis inſeruntur. Inciſoribus omnino caret.*

Thus Mr. *Ray* deſcribes the *Teeth* of this *Animal:* And if we compare Dr. *Blair*'s Words with his, and the Particulars of both Accounts with the Deſcription and Figures we have given of the *Teeth* dug up in *Ireland*, and obſerve how they all agree exactly, even ſo as one may ſay they tally together; I think it will amount to nothing leſs than Demonſtration, and that all our *Ideas* have been taken from one and the ſame *Natural Object*; and as they, ſo we, muſt certainly have deſcribed no other *Teeth* but thoſe of the *Elephant*.

But then perhaps it will be aſk'd, what is become of all the reſt of the *Teeth*, that were in the upper Jaw, which being as firm and ſolid Bones, as thoſe that are here preſerved, might for the ſame Reaſon have ſtill remained entire.

But

But ſince we find it otherwiſe, 'tis obvious to imagine a probable Conjecture, how this might come about. From what Mr. *Nevil* mentions, 'tis plain that the Bed where all theſe Bones were found, muſt once have been the outward Surface of the *Earth*, the *Green-Sod*, producing *Ruſhes*, *Ferns* and *Nuts*: And when the heavy Beaſt firſt fell dead upon this Spot, the Skull, with all the Bones and Teeth of the upper Jaw, being the higheſt Parts of the *Animal*, might likely fall in ſuch a Poſture, as to be expoſed ſome while above the *Earth*; though thoſe of the under Jaw firſt coming to the Ground, might make themſelves a Bed, and being cover'd with the Mould, remain preſerved; whilſt the upper Teeth, and moſt of the other Bones, lying expoſed to the Injuries of the Air and Weather, before they got a Covering, might rot and quickly moulder all away.

But though this be allowed, yet ſtill a greater Difficulty remains unſolv'd; how this large-body'd *Animal*, a *Native* of the remote warm *Climates* of the *World*, ſhould be depoſited in this wild *Northern Iſland*, (where *Greeks* or *Romans* never had a footing) ſo many Miles from Sea, and diſtant from thoſe Places of the Iſle, where People might moſt probably reſort.

And to make the Difficulty yet greater, we muſt conſider, not only from the dark black Colour of the Teeth, contracted by their lying long under Ground, and the remarkable Alteration wrought on their bony Subſtance, which (by the mineral Steams and Exhalations it has imbib'd whilſt it was in the Earth) is now become more ſolid, hard, and ponderous, than it was naturally at firſt, (nay, in ſome Parts we find it plainly petrified) but alſo from the periſhing of all the other Bones of the Animal's Body, and from the conſiderable *Depth* of *Earth* that covered thoſe that were found: We muſt conclude from hence, that they have lain in this Place for many Centuries: I won't ſay, with Mr. *Nevil*, ever ſince the *Flood*, becauſe I can't ſuppoſe that the ſlight Texture of vegetable Subſtances, *Nuts* and the Seeds of *Ruſhes*, could poſſibly have been preſerved ſo long: But this, at leaſt, may ſafely be affirmed, that theſe Remains muſt be Cotemporaries with ſome of the remote Ages of the *World*; which carries us ſo far back into the earlieſt Times, that we can never imagine the rude Inhabitants of *Ireland*, or any of their neighbouring Countries, were Maſters of ſo much Art, in thoſe Days of Ignorance and Darkneſs, as to make Carriages by Sea ſtrong and capable, or of Curioſity and Politeneſs enough, to tranſport a Beaſt of this large Size from thoſe far diſtant Cobntries, where 'twas bred.

Theſe Conſiderations, grounded on other Inſtances of the like kind, make me inclined to think, this *Elephant* might not be brought hither by any Care or Induſtry of *Man*; but the Surface of this Terraqueous Globe might, in the earlieſt Ages of the *World*, after the *Deluge*, but before all Records of our oldeſt *Hiſtories*, differ widely from its preſent *Geography*, as to the Diſtribution of the *Ocean* and *Dry-land*, its *Iſlands*,

Iſlands, *Continents*, and *Shores*, ſo as to allow this Beaſt, and others of its Kind, for ought I know, that may by ſome ſuch Accident hereafter be luckily diſcovered, a free and open Paſſage into this Country from the Continent.

For otherwiſe, how can we ever explain that that other vaſt large ſtately *Animal* the *Mooſe-Deer*, little inferior to the *Elephant* it ſelf, could have been brought to *Ireland*, (where elſewhere I have ſhewn it formerly was common) from diſtant *North America*, even long before that Quarter of the World was known, and is the only Region, I can hear, where this great Beaſt is found at preſent.

And can we well imagine, that *Foxes*, *Otters*, *Badgers*, *Tygers*, *Wolves*, with *Linxes*, and ſuch ravenous *Animals*, as we have been told, have lately been diſcovered by the great Snows that fell this preſent Winter, in the *Iſland* of *Sardinia* and other Places, ſhould ever be imported (being uſeleſs noxious Beaſts of Prey) by the Induſtry of *Man*, to propagate in *Iſlands?*

Nay, how can we ſuppoſe, that *Birds* of ſhorteſt Flight, the various ſorts of poiſonous *Serpents*, and of offenſive *Creeping Vermin*, with all the various Tribes of ſmaller *Inſects*, could poſſibly be found in *Iſlands*, unleſs they had been ſtock'd with thoſe Inhabitants, when the Intercourſe between them and the Continent was free and open?

But in whatever Manner this *Elephant* might firſt have made its way for *Ireland*, this is beyond Diſpute, that the *Bones* of *Elephants* have been diſcovered deep under Ground, in other Places, as well as this Kingdom, and thoſe too out of the Way, far diſtant from the native Countries of this Animal.

For not many Years ago, in a Hill near *Erfurt*, a Town of the *Upper Saxony* in *Germany*, ſeveral Parts of the *Skeleton* of an *Elephant* were dug up; an Account of which is given by *Tentzelius**.

* *Vid.* ſupra, V. II. C. III. S. XXXVIII.

And I am well perſuaded, by the beſt Conſtruction I can make of thoſe imperfect and obſcure Accounts, we have in *Evert Iſbrand Iddes* curious Travels from *Muſcovy* to *China* over Land, *Chap.* 6. (which he confeſſes he only gather'd from the barbarous *Oſtiacks*, Inhabitants of that Country) concerning the vaſt *Teeth* and *Bones* and *Limbs* of **Mammuths**, as he calls them, frequently found (and diligently ſought after to make Profit of them) in the Hills and Banks of ſeveral Rivers in *Siberia*, the *Keta*, *Jenize*, *Trugan*, *Montgamſea*, and *Lena*; that they are nothing elſe, but the Remains and *Skeletons* of *Elephants* buried there, and accidentally diſcovered by the Earth's opening, and falling down, on the ſudden Thaws, after ſevere long Froſts.

Mr. *Cambden* in his *Britannia* is of Opinion, that thoſe great monſtrous *Teeth* and *Bones*, which he takes Notice to have been at ſeveral Times dug up in many Parts of *Great Britain*, muſt have been the Remains of *Elephants*; but then he thinks, they muſt be of thoſe that *Dion Caſſius* the Hiſtorian tells us the *Roman* Emperor *Claudius* brought over, when he made his Expedition into that *Iſland*. But that this truly

truly is ſo, I own is but Surmize as yet, and has not been fairly proved by him or any other.

What Mr. *Somner* * has publiſhed is more remarkable; he informs us, that in the Year 1668, in the Village of *Chartham* near *Canterbury*, in *England*, *digging within 12 Rods of a River, they found a Parcel of ſtrange monſtrous Bones, ſome whole, ſome broken, together with four Teeth, perfect and ſound, each weighing ſomething above half a Pound, and ſome of them almoſt as big as a Man's Fiſt. They are all Cheek Teeth or Grinders; the Earth in which they lay being like a Sea Earth, or Fulling-Earth, with not a Stone in it.*

* *Vid.* ſupra. p. 222.

'Tis obſervable how this Account, in many of its Circumſtances, agrees with that of Mr. *Nevil*'s; as that the Teeth were all Grinders, four in Number, found with other large broken Bones, near a Brook, and in a Claiey Earth, without a Stone: But then the Weight and Magnitude of our largeſt *Teeth* ſo far ſurpaſs thoſe, that were found in *England*, that theſe did not come up to a fifth Part of thoſe, which ſhows, they could not be the Teeth of the ſame Animal. I muſt confeſs, the Author does not ſo much as ſuſpect they were *Elephants Teeth*, but on the contrary, is of Opinion that they belong'd to another *Species*, the *Hippopotamus* or *River-Horſe*, a Beaſt that's yet a greater Stranger in theſe Parts of the World, than the *Elephant* itſelf; and therefore its Paſſage hither can never be accounted for, but by ſome ſuch like Suppoſition, as we have made.

Mr. *Luffkin* † differs in his Judgment from Mr. *Somner* about theſe Teeth, which he thinks muſt have been *Elephants Teeth*; as he is poſitive thoſe large Bones he deſcribes in the ſame Letter, and found near *Harwich* in *Eſſex*, certainly muſt have been.

† *Vid.* infra. p. 245.

Not having ſeen any of the Bones or Teeth concern'd in this Controverſy, either thoſe that were found in *Kent*, or thoſe in *Eſſex*, I cannot well take upon me to determine any thing in this Matter: But this at preſent I can ſafely ſay, that if the *Figures* of the *Teeth* given us by Mr. *Somner* ‖ be genuine and well expreſt, they no way ſeem to agree either in Shape or Make, or in that particular and *Characteriſtick* Work on the grinding Superficies, with the *Teeth* of the *Elephant*; or with the Deſcription and Figures we have given, which are correct and natural.

‖ *Vid.* Fig. 26, 27.

I am inclined to think, (even from theſe imperfect Hints) that if we had more correct Hiſtories and Obſervations of this kind, made in diſtant Couutries, ſkilfully regiſtred, with all their inſtructive Circumſtances, they might lead us into great and momentous *Truths* relating to the *Deluge*; to the wiſe Methods of Providence, in repleniſhing all Regions of the *World* with *Animal Beings* ſoon after the *Flood*; and to the Knowledge of ſeveral important Changes, that may have happen'd on the Surface of this our *Terraqueous Globe*.

[*The Tooth* Fig. 34. *is* Nine *Inches and a* half *long, whereby the Magnitude of the others may be eſtimated.*]

This

Remarks *by Dr.* E. Halley. *ibid.*

3.] This Account of Mr. *Nevil*'s, with Mr. *Molineux*'s Draughts of the Teeth, and his Remarks upon them, having been produced and read before the *Royal Society*, they order'd, that what Teeth they had of like ſort ſhould be look'd out and laid before them; to which Sir *Hans Sloan* was pleaſed to furniſh a yet greater Variety, out of his Collection of *Natural Rarities*. And to obviate all Doubts, there being at this Time in *Weſtminſter* the entire Skull of a large Elephant with the Teeth in it, That was likewiſe ordered to be viewed and compared with the Figures: Which done, it appeared that the Teeth in Queſtion could be no other than thoſe of an Elephant.

By this Enquiry we were likewiſe ſatisfied, that the Number of Teeth found being but four, was no Objection; it appearing that the Number of *Molares* in this Animal is not certain. *Pliny*, *Lib.* XI. c. 37. ſays expreſly, *Dentes Elephanto intus ad mandendum quatuor, præter eos qui prominent.* And in the Remains of that mighty Elephant deſcribed by *Tenzelius* *, there were no more than four Teeth found. In that at *Weſtminſter* there were ſix, *viz.* one in each lower Jaw, and two in each of the upper, whereof the inner Tooth is about three Times as long as the other, and both together longer than thoſe of the under Jaw, by about an Inch; the upper ſmall Teeth being much worn by grinding. Theſe we have thought fit to repreſent by *Fig.* 32. ſhewing the rough grinding Surface of the left under Tooth, being conſiderably *concave*; and by *Fig.* 33. the ſame Roughneſs on the upper Teeth is ſhewn, having a *Convexity* tallying with the *Concavity* of the under, which is a Circumſtance not obſerved by any of thoſe that have deſcribed them.

* *Vid.* ſupra, V. II. C. III. S. XXXVII.

Fig. 32.

Fig. 33.

And altho', by the Obſervation of Mr. *Du Verney*, Dr. *Moulins*, and Dr. *Blair*, who diſſected three different Elephants, it appears, that each of them had eight *Molares*; yet from theſe it is alſo evident, that in the Diviſion of them Nature obſerves no Rule: For Dr. *Moulins* found the two Teeth, in each of the upper Jaws of that he diſſected, to be divided after a different Manner; ſo that the inner Tooth on the one Side, and the outer on the other, was bigger than its adjoining fellow, yet not ſo as to be very unequal: And Mr. *Du Verney* and Dr. *Blair* had on both Sides the much greater Tooth outwards: Whereas the *Weſtminſter* Skull, on the contrary, has only a ſmall one outwards, and the much greater Grinder within. All which conſidered, we may with Aſſurance conclude, that this Elephant found in *Ireland* had but four Teeth in his Head when he died; and that the two greater were thoſe of the upper Jaws, and the other two thoſe of the under.

Again, by the Size of the grinding Part, we may conclude theſe to be the Teeth of a very young and ſmall Elephant; ſince they are not much above half the Length of thoſe, that are to be ſeen at *Weſtminſter*, which belonged to a Beaſt of not more than between 10 and 11 Foot high; nor much above one Third of the Length of a Foſſil Elephant's Grinder in the *Royal Society*'s Repoſitory, the which is here repreſented by *Fig.* 34. Hence it is not to be wondered at, that the

Fig. 34.

Bones

Bones of ſo young an Animal, having not acquired their Firmity, as being in a growing State, ſhould be diſſolved by long lying in the Earth, as alſo the Roots of the Teeth.

Matthew Paris in his Hiſtory aſſures us, that in his Time *Louis* IX. (afterwards St. *Louis*) King of *France*, made a Preſent of an Elephant to his Cotemporary *Henry* III. of *England*, and that in the Year 1255, after the *Engliſh* had been fourſcore Years Maſters of *Ireland*. Of this, ſays *Matthew*, *Nec credimus, quod unquam aliquis Elephas viſus eſt in* Angliâ, *præter illum.*

An Account of Large Bones, *found near* Colcheſter, *by Mr.* J. Luffkin n. 274. p. 924.

X. Having read Mr. *Somner*'s Account of ſtrange Bones found at *Chartham*, I think it not improper to acquaint you with ſomething like it: That in 1701, at *Wrabneſs*, a ſmall Village, ſituate in the moſt Eaſtern Parts of *Eſſex*, upon the River *Stour*, near *Harwich*, divers Bones of an extraordinary Bigneſs were found at fifteen or ſixteen Foot beneath the Surface of the Earth, in digging for Gravel to mend the Roads with, &c. the largeſt and moſt remarkable of which was procured and ſent to me by Mr. *Rich*, Miniſter of the Place.

We read in *Cambden*, p. 351. that in the Time of King *Richard* II. and in the Reign of Queen *Elizabeth*, there were found in the moſt Eaſtern Promontory of *Eſſex*, at a Place call'd *Odulfineſs*, which I take to be *Walton*, large Teeth, and Bones of an extraordinary Bulk, which were eſteemed the Bones of Giants. But Mr. *Childrey* in his *Britannia Baconica*, p. 100. rather thinks them to be the Bones and Teeth of ſome Elephant, buried there by the *Romans*.

That theſe were the Bones and Teeth of ſome Elephant, I am prone to believe; firſt, becauſe they far ſurpaſs in Magnitude the Bones, &c. of the largeſt Creatures that we have at this Day in our Iſland.

Secondly, Becauſe 'tis evident from *Dion Caſſius*, as quoted by Mr. *Cambden* (See the *Romans* in *Britain*, and in his *Britannia*, pag. 347.) that Abundance of Elephants were brought over into *England* by the Emperor *Claudius*, in his Wars with the *Britains*; even into *Eſſex*, as appears from the ſame *Dion*, a little after in theſe Words: *Claudius* having at laſt joyned *Plautius*, and took the Command of the Army, paſſed the River (meaning the *Thames*) and upon a fair Engagement with the Enemy, who were poſted there to receive him, obtained the Victory, took *Camalodunum*, &c.

Thirdly, In comparing this Bone with the Oſteology of Dr. *Moulins*, in his Anatomical Account of the Elephant burnt at *Dublin*, &c. I find it perfectly to agree to and with the *Os humeri* thereof, not only to outward Appearance or Form, but to Meaſure alſo; from which Circumſtances we may conclude, that theſe were the Bones, &c. of ſome Elephant, rather than of any other Animal.

And it does ſeemingly appear to me, that theſe Teeth and Bones mention'd by Mr. *Somner*, might have been the Teeth and Bones of ſome Elephant, rather than that of the *Hippopotamus*: and that,

Firſt, in Reſpect of the Place; for, as Mr. *Cambden* ſays in his *Britannia*, p. 197. ſpeaking of *Chilham* in *Kent*, of which this *Chartham* is a neighbouring Village, ſituate in the ſame Down, and on the ſame River *Stour*, that it is a current Report amongſt the Inhabitants, that *Julius Cæſar* encamp'd there, in his ſecond Expedition againſt the *Britains*; and thence it was called *Julham*, as if one ſhould ſay, *Julius* Station or Houſe.

It appears farther, *Britan.* p. 208. that *Rhutupiæ* (which whether *Richborough* or *Stoner* matters not) ſituate near the preſent *Sandwich*, was the Place of *Claudius*'s landing in *Britain*; and that through this Down was his neareſt Paſſage to the *Thames* whither he was going, is indiſputable. So that 'tis highly probable, that during the Stay, paſſing or repaſſing of theſe *Roman* Armies through theſe Downs, ſome one of their Elephants might periſh or dye, and be buried there.

Secondly, By the Teeth themſelves, for if you compare the Icons given by Mr. *Somner*, with the Deſcriptions of Dr. *Moulins*, p. 40. you will find them the very ſame as to Breadth and Depth, *&c.* and their being *Molares*; for, ſays the Doctor, theſe eight (which were all the Elephant had, beſides the two Tuſhes) were *Molares*, for he had no *Inciſores*.

And laſtly, to ſolve that great Difficulty which obliged this Gentleman to imagine this Down to have been an *Æſtuary*, that his *Hippopotamus* might therein dig itſelf a Grave, otherwiſe how ſhould theſe Bones be found at ſuch a Depth? For who with Reaſon (ſays Mr. *Somner*) can imagine, that any Land Creature could ever have had (at firſt) ſo deep a Burial?

But 'tis eaſily explained, why theſe Bones ſhould at this Day be found at ſuch Depths, if we conſider the Alteration or riſing of the Valleys, by the continual waſhing down of the looſe Earth or Soil by the Rains and Snows from the adjacent Hills, and by the annual Rollings of the Graſs, Sedge, *&c.* for Proof whereof take the following Inſtance from Dr. *Plott*'s Nat. Hiſt. of *Staffordſhire*, Chap. vi. p. 48. p. 220. ſpeaking of a Moſs, *&c.* wherein there was found a Lump of Coins of *Edward* IV. of *England* (ſuppoſed to be loſt in a Purſe or Cloth now rotted away) at 18 Foot deep, which being about 200 Years ſince (that is, when they were found) whoever pleaſes to compute it, will find this Moſs grew about one Foot in 11 Years, or one Inch *per Annum* and $\frac{1}{12}$ *proximè*. Divers other Inſtances of Alteration are mentioned in the ſame Hiſtory, as in Chap. 3. par. 11, 12. and Chap. 6. par. 45, 46, 47, 48, *&c.* Now it will be eaſily granted, that if this Moſs grew or advanced itſelf above its Surface 18 Foot in 200 Years, then this Vale or Down might advance itſelf 17 Foot in almoſt 1700 Years.

Coins, *&c.* *found* under Ground *in* Lincolnſhire, *by* — n. 279. p. 1156.

XI. 1.] In *July* 1701. one *Edward Lenton*, who lives with one *Philip Wolverſton* of *Fleet* in *South Holland* in *Lincolnſhire*, being about to fence in a Hay-ſtack, and digging a Grip for that Purpoſe about the Depth of half

half a Yard, ſtruck his Spade upon a Pot, which when he broke, there was no leſs than 36 Pound Weight of old *Roman* Copper Coin found in it. The Pieces were found ſet in Rows edge-ways, one by another, and ſtuck ſo together with the Verdigreaſe or Ruſt of Copper, that many of them required a Chizel, or ſome ſuch Thing, to ſeparate them; but being ſeparated, clean'd and brighten'd, the Heads or Figures of all, or moſt of them, were very fair, (ſome as when newly ſtamped) and the Inſcriptions of many are very legible. The Fellow careleſly gave them away, and diſperſed them up and down the Country to ſuch as deſired them. Here was amaſs'd together a great Variety of Coins in this Pot: They ſay Dr. *Hart* of *Wiſbich*, has a Dozen of the beſt Pieces; and an Apothecary at *Long Sutton* a Score of the ſame, the largeſt and moſt legible: And *Philip Wolverſton* himſelf has two or three, ſo very large and fair, that he will not part with them. The Place where they were found, is in the midſt of the vaſteſt Flat or Level in *England*, and in a Ground that for many Ages paſt uſed to be cover'd with Water in the Winter, and over-grown with Reed in the Summer. 'Tis about a Mile and a half South *by* Weſt from *Fleet Church*, and about as far South *by* Eaſt from *Holbeach*. There are no Banks or Hillocks, old Works or Ruins, to be ſeen near it; nor any Remains or Tokens of any Thing extraordinary to have been there; (but the old Sea Bank about two or three Miles off; which *Dugdale* from a Paſſage in *Tacitus* believes to be caſt up by the *Roman* Soldiers). But all is as flat as the Sea, and a low Country, producing a coarſe flaggy Graſs for the moſt part, round about it. The Pot, which was narroweſt at the Top and Bottom, but thicker in the Middle, had an Inſcription about it, which, though it ſeemeth in ſome of the Shreds or Pieces to be fair at firſt Sight, yet is not legible, though what it may be to Men ſkill'd in Antiquities, I know not.

Near the River *Welland*, (about 5 or 6 Years ago) that runs thro' the Town of *Spalding* in *Lincolnſhire*, at the Depth of above eight or ten Foot, there were found *Jettys*, as they call them, to keep up the old River's Bank, and the Head of a Tunnel that emptied the Land-water into the old River; and at a conſiderable Diſtance from the preſent River, I gueſs 20 or 30 Yards, there were dug up (about the like Depth) ſeveral old *Boats*, which Things ſhew, that anciently the River was either much wider than now it is, or ran in another Place, or both. On the other, *viz.* the North-Weſt Side of the River, and more upwards in the Town, were digg'd up (at about the aforemention'd Depth) the Remains of old *Tanvats* or *Pits*, a great Quantity of *Ox-horns*, and *Shoe-ſoals*, (of a ſtrange Form) and I think the very Tanners Knobs, *&c.* which Things ſhew, that the Surface of the Country lay anciently much lower than now it does, and has been raiſed by the Sea's throwing in its Sand in the Maritime Parts (now moſt inhabited) and by the *Moor* or *rotted Sedge* in the fenny Parts next the high Country; the whole Level is about 50 Miles in Length, and 30 Miles over in the broadeſt Parts. Boats, Ox-horns, *&c.*

Parts. No Record (printed or MS.) or Tradition whatſoever, (that I ever heard of) tell us when theſe Mutations here diſcoverable happen'd.

One Thing farther I have to add, that lately at the laying of the preſent new Sluice or *Goat* (as they call it) at the End of *Hamorebeck*, at its Fall into *Boſton* Haven, taking up the Foundation of the old *Goat*, they met with the *Roots of Trees*, many of them iſſuing from their ſeveral *Poles* or *Trunks*, ſpread in the Ground, which when they had taken up (Roots and Earth they grew in) they met with a ſolid, gravelly, and ſtony Soil, of the high Country Kind, (but black and diſcoloured by the Change that had befallen it) upon which hard Earth they laid the Foundation of this new *Goat*: Where theſe Roots were dug up, was certainly the Surface of the old Country, the certain Depth whereof, I cannot now tell, but that it was much deeper than that at *Spalding*, as the Land is there at preſent higher. The *Archimedean* Screw, or ſcrew-like Trunk or Cylinder, by which the Workmen cleared themſelves of Water, was very pretty.

A Remark, *by Mr.* R. Thoreſby. *ibid.*

2.] The Matter of Fact in theſe Relations, is indiſputable, this worthy Perſon being an Eye-witneſs; and I take it for an experimental Confirmation of Mr. *Ray*'s Opinion, that the great Level of the Fens running through *Holland* in *Lincolnſhire*, the Iſle of *Ely* in *Cambridgeſhire*, and *Marſhland* in *Norfolk*, was ſometime part of the Sea, and atterated by Earth brought down by Floods from the upper Grounds, by the great Quantity of Mud there ſubſiding, which by Degrees raiſed it up. The Form of the *Shoe* was much like thoſe found with ſome Urns at *Kirby Thore* in *Weſtmoreland*, as deſcrib'd in *Ph. Tranſ.* N. 158*.

* *Vid.* ſupra, V. III. P. II. S. XXVI.

Of an uncommon Sinking *of the* Earth, *by Mr.* J. Sackette. n. 349. p. 469.

XII. I ſhall give the beſt Account I can, of what is remarkable, and known almoſt to all hereabouts, concerning the preſſing forward of the Cliffs, and ſinking of the Hills in the Neighbourhood of the Town of *Folkſtone* in *Kent*. I ſhall give a Sketch of the Situation of the Country, by deſcribing a ſtrait Road from what we call the *Mooring-Rock*, to *Tarlingham-Houſe*; the Manner of the Country, as to the Riſing and Falling, being much the ſame, for about a Mile on either Hand of the Road deſcribed.

Fig. 35.

A, The *Mooring-Rock*, about half way between high and low Water-Mark. *B*, the Foot of the Cliff, 50 Yards from the Rock. *C*, the Top of the Cliff, about 6 Yards high. *C D*, a Plain of 50 Yards. *D E*, a cragged Cliff, of 60 Yards high. *E F*, a Plain above a Mile long. *F G*, an Hill of ſteep Aſcent, near half a Mile. *G H*, the Land from the Top of the Hill to the Houſe, near a Mile. *I Tarlingham Houſe*, lying near two Miles and a half N. N. W. from the Rock. *E G H*, a Line of Sight. *K B L*, the Shore at High-Water Mark.

The *Mooring-Rock* (though it lies ſurrounded with great Numbers of other Rocks) is it ſelf a moſt noted one, known by this Name, Time out of Mind. At this Veſſels uſe to be moored, while they are loading other Rocks, which they take from hence, not only for our own

own *Pier-Heads*, but for thoſe of *Dover-Pier*, and a very great Quantity of them were ſhipp'd in the Time of *Oliver*'s Uſurpation, and carried to *Dnnkirk*, for the Service of that Harbour.

This Rock has remain'd fix'd thus, for the Memory of Man; and old Men have obſerved, that for forty Years and upwards, the Diſtance between it and the Foot of the leſſer Cliff *A B*, has been much the ſame; neither can they be much out in their Gueſs, the Diſtance being ſo ſmall. Though there ſeems nothing extraordinary in this, yet its what they take ſpecial Notice of, to their great Surprize: For they ſay, and prove by good Marks and Tokens, that the leſſer Cliff *B*, *C*, has been conſtantly falling in, inſomuch, that from Time to Time, in their Memory, near 10 Rods forward to the Land has been carried away by the Sea. From whence, as it appears that the Plain between the Top of the leſſer Cliff and the Foot of the higher *C D*, has been formerly double the Breadth that it is at preſent, ſo the Diſtance between the Rock and the Foot of the leſſer or lower Cliff *A B*, ſhould have increaſed in Proportion, and would have been double at preſent, to what it has been formerly. But this Diſtance remaining the ſame, or rather leſs, (in the Opinion of many) is what is greatly wonder'd at: Nor can it be accounted for otherwiſe, than by ſuppoſing, that the Land preſſing forward into the Sea, is waſhed away by the high Tides; and, as often as this happens, preſſes forward again. This preſſing forward of the Land into the Sea, would be incredible, were it not ſhewn to be Matter of Fact; and that not only at this one Place of Obſervation, but by like Obſervations all along this Coaſt, as far as the Situation continues the ſame.

Now let us climb both theſe cragged Cliffs, and place our ſelves at the Top of the higher one, at the Point *E*. And here we are to obſerve, that (as old Men inform us) upward of forty Years ago, not ſo much as the Top of *Tarlingham-Houſe* could be diſcern'd, neither from hence, nor yet a good Diſtance off at Sea; but it diſcover'd it ſelf by Degrees; till at this Day, not only the whole Houſe, but a great Tract of Land below it, is plainly to be ſeen, as in the Line of Sight *E*, *G*, *H*. In this there can be no Fallacy, and we can aſcribe it to nothing leſs than the ſinking of the Hills (for their Tops could never wear away conſiderably, being always cover'd with Graſs, and never broken up by the Plough, or otherwiſe). Theſe Hills are all of Chalk, and have probably very large Caverns within, Springs of Water always flowing plentifully from the Foot of them; and I have had it obſerv'd to me, that upon their Tops frequent Cracks have been taken Notice of. Whatever be the Cauſe of it, 'tis not to be doubted, but that theſe Hills are greatly ſunk. And this ſinking of the Hills, the People at this Place believe, forces the Cliffs and all the Land forward into the Sea. The Cliffs conſiſt of great ragged Sand Stones, till we come to near a Yard (at ſome Places more) of the Bottom; then we meet with what they call a Slipe, *i. e.* a ſlippery ſort of Clay always wet.

Upon

Upon this Slipe, at the Bottom, they preſume, that the hard ſtony Land above, ſlides forwards toward the Sea, as a Ship is launched upon tallow'd Planks.

We whoſe Names are under-written, do hereby teſtify the Truth of the Matters of Fact in this Account; *Benjamin Maſter*, a Jurat of the Town, aged 74. *Robert Hammond*, Sen. a Jurat of the Town, aged 77. *William Godden*, a Fiſherman, aged 74. *Thomas Marſh*, a Fiſherman, aged 72. *William Hall*, a Fiſherman, aged 73. *James Godden*, a Fiſherman, upward of 60.

Part of a Hill *ſinking down in* Ireland. *Communicated by the* Biſhop *of* Clogher. n. 337. p. 267. Fig. 36.

XIII. Let *S*, *T*, *Fig.* 36. repreſent part of the Ridge of an Hill, gradually riſing from *S* to *T*, for near half a Mile; and *S*, *T*, *W*, *U*, the North-ſide of the Hill, with a Declivity from *S* to *U*, and from *T* to *W*. The perpendicular Height at *X*, to the Plain of the Bottom at *Y*, 150 Feet, and the Slope Line or *Hypotenuſe X*, *Y*, 630 Feet.

The Declivity is pretty uniform from *X* to *L*, and from *L* to *Y* conſiderably ſteeper: The Bank *A*, *E*, *F*, *D*, overgrown with ſhrubby Wood, all the Ground on the Side of the Hill being firm, green, and arable; of a mixed Soil, Clay and Gravel, but more clayey.

On *Tueſday* the 10*th* of *March*, 1712-13. in the Morning, the People obſerved a Crack in the Ground, like a Furrow made with a Plough, going round from *A*, by *B C*, to *D*. They imputed this to (what they call) a Thunderbolt; becauſe there had been Thunder and Lightning on *Monday* Night. But on *Tueſday* Evening an hideous dull Noiſe raiſed their Curioſity; and they obſerved that the whole Space *A*, *B*, *C*, *D*, containing about three *Iriſh* (i. e. $4\frac{3}{4}$ *Engliſh*) Acres, had been all Day in a gentle Motion: And the Noiſe continued all Night, occaſioned by the rubbing of Buſhes, tearing of Roots, rending and tumbling of Earth. The Motion ceaſed on *Wedneſday* after Noon, when they ſaw the Buſhes on the Bank *E F*, were removed, ſome ſtanding and ſome overthrown, to the plain Meadow *Y y*. The green Ground above *E F*, when it came to the Top of the ſteep Part at *E F*, rent with hideous Chaſms, ten, fifteen, or twenty Feet deep, and tumbled down in Rolls of a Yard or two thick, and ten or twenty long and broad; not unlike a ſmooth Water breaking over a Cataract, and tumbling in Waves below.

There was a Precipice at the Top *X x*, 65 Feet perpendicular, making the Slope-Line *X x*, 126 Feet. The Ground from *x* to *L*, was made more level, the whole perpendicular Height of *x* not exceeding the Plain of *L*, above 30 Feet; but the Ground at *L*, in the whole Line from *E* to *F*, was mounted above 20 Feet higher than the unmoved Ground on either Side at *E* and *F*; and the Height of *L*, above the Plain of *y*, is 55 Feet.

There was a Ditch *H*, *I*, went croſs the Ground, which being broken off at *o*, *o*, is removed, together with the moving Part, 34 Feet lower down than the immoveable; but, at the Bottom *y*, it is tumbled 60 Feet over the plain Meadow. The Breadth at the Bottom *a*, *b*, is 400 Feet, and at *c*, *d*, about 300.

The

The whole Face of the Precipice *X*, *x*, is of a blue Clay, mixed with many little blue Stones. The Metal is very hard when dry; but upon any Rain ſoftens to a kind of Mortar, without the Degree of Toughneſs and Stiffneſs that is Natural to Clays. It is very much like that Gravel or Sand (as they call it) which is ſomewhat of a grey marly Nature, and with which of late they ſo much improve the ploughed Land in this Country.

About *x*, there are Chaſms or Gapings full of Water, which make a Rill down the *Hiatus B*, *E*, *A*, but in no greater Quantity, than might have been expected from a Well ſunk to a leſs Depth. Though I was told, that there were Holes in the higher Mountains, that receiv'd Water under Ground; yet I can find no ſuch Thing, nor any Symptoms of a Current under Ground, either where it enters or riſes, in all the neighbouring Ground for ſome Miles.

It ſeems to me, that there has been no Vacuity under Ground to receive the ſubſiding Earth; for what the Bank *E*, *L*, *F*, is raiſed higher, and what is tumbled down to the Plain *a*, *b*, may very well compenſate the Subſiding at the Precipice *X*, *x*.

Before the Rupture, the Declivity from *X* to *L*, was not altogether uniform, but was hollower where *x* is now, than the adjacent Parts: It might have been, by the Deſcription I have from the People, 10 Feet deep in the Middle, and 100 Feet Diameter; and they have a Tradition, that this was made by a Subſiding before the Forty-one Wars, (the oldeſt *Epocha* the Country *Iriſh* know.)

It lies in the Lands of *Slat-beg*, two *Engliſh* Miles S. W. of *Clogher*, on Mr. *Mowtray*'s Eſtate.

I have inquired diligently of the Neighbours, if they found any Shocks or Indications of an Earthquake, but don't find the leaſt Appearance of any.

They impute it to the great and conſtant Rains we have had laſt Harveſt and Winter, which have ſoak'd and ſteep'd all the Ground, but cannot gueſs after what Manner they ſhould produce this Effect; for it is impoſſible any Water ſhould ſtand on the Ground, or in the Vicinity, it being all on the Declivity of the Hill.

XIV. This Iſland goes by the Name of the *Sunk* Iſland, ſo called I ſuppoſe from the ſinking Marſh Ground about. It is yet within the Memory of Man ſince it began to raiſe its Head above the Ocean, there being ſeveral old People here alive who can remember when there appeared nothing of it but a waſte and barren Sand; and that only at Low-Water too; when for the Space of a few Hours it ſhewed its Head, and then was buried again till the next Tide's Retreat: Thus ſucceſſively it lived and died until the Year 1666, when it began to maintain its Ground againſt the Inſult of the Waves; about which Time it began to be reſcued wholly from future Danger, by the Care and

An Account *of the* Sunk Iſland, *in the* Humber, *recovered from the* Sea: *Communicated by* J. Chamberlayne, *Eſq*; n. 361. p. 1114.

and Induſtry of Colonel *Gilby*, who having, as I am inform'd, a Leaſe or Gift of it from the Crown, did raiſe Banks about the riſing Grounds of it, and ſo defending it from the Encroachments of the Water, it became firm and ſolid, and in a ſhort Time afforded good Paſturage for Sheep and other Cattel. The Expences at firſt, to improve it to what it is, muſt needs have been very conſiderable; it being encompaſs'd with high Banks, and deep Canals for receiving and diſcharging the Liquid Element, which every now and then notwithſtanding threatens to repoſſeſs it, but hitherto in vain.

This Iſland is now about 9 Miles in Circumference, within the Banks, which ſeem to render it impregnable againſt all future Attacks of the Sea, and is of a very fat and fertile Soil, affords good Graſs, Corn and Hay, and is repleniſhed with numerous Flocks of Sheep, which are of a larger Size and finer Wool, than thoſe in *Holderneſs*, from which it is divided by about two Miles in Water; and from *Lincolnſhire* by about four. It is ſtor'd with vaſt Numbers of Rabbits, that ſeem innumerable, they appearing through all Parts in prodigious Swarms; their Skins are counted the fineſt in *England*, of a dark Mouſe-Colour, ſhagg'd, and ſoft as Silk.

There are alſo Cows and Horſes feeding conſtantly in the Place, with great Plenty of Wild Fowl.

The Inhabitants are not ſo numerous, there being only three Families, that live conſtantly upon the Place; however they are never too ſolitary, there being Abundance of Workmen and Labourers, that continually reſort thither, ſometimes I am told to the Number of a Hundred and upwards, for the repairing of the Banks, *&c.*

The yearly Income of the Proprietor amounts to about 800*l.* and pays the King's Taxes to thoſe who collect for the *Eaſt-Riding*, and is uſually uplifted by thoſe of the Liberty and Townſhip of *Ottringham*, from the Marſhes of which there is a Paſſage over the Sands to the *Sunk* at Low-water. But this Cuſtom of paying the King's Ceſs to them, proceeds only from the Conveniency, not Neceſſity; for it never belong'd to that, or any other Pariſh, ſo that I cannot reſolve you, in what Dioceſe this Iſland lyes, unleſs it had been united to ſome neighbouring Pariſh, or converted to one of itſelf; which if effected, the Tythe of Lambs, Wool and Rabits, *&c.* would make up a handſome Benefice. It lyes nearer indeed to the Dioceſe of *York*, by at leaſt two Miles, than to that of *Lincoln*, being two Miles South of *Holderneſs*, in the River *Humber*, and four Miles North of *Lincolnſhire*, &c.

An Account of the Sinking *of* 3 Oaks *into the* Ground: *Communicated by Mr.* P. le Neve. n. 355. p. 766.

XV. On the 23*d* of *July* 1717, near the Seat of Sir *Charles Potts* at *Manington* in *Norfolk*, in the Day Time, to the great Aſtoniſhment of thoſe that were preſent, firſt one ſingle Oak, with the Roots and Ground about it, was ſeen to ſubſide and ſink into the Earth; and not long after, at about 40 Yards Diſtance, two other Oaks, that were contiguous, ſunk after the ſame Manner into a much larger Pit, being about 33 Feet

Fig. 28.

Fig. 32.

Fig. 33.

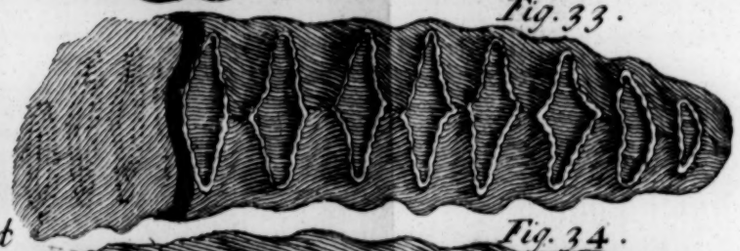

Fig. 34.

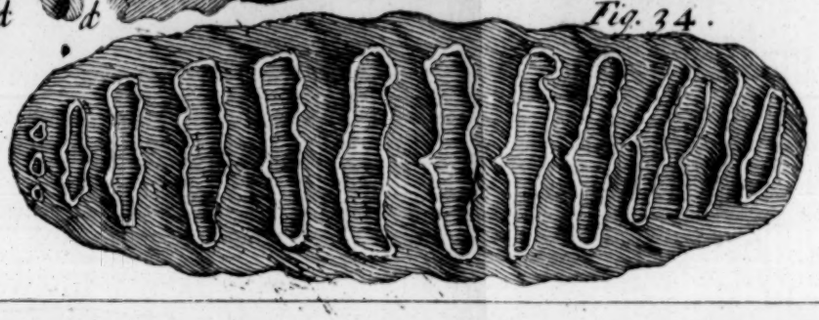

Fig. 30.

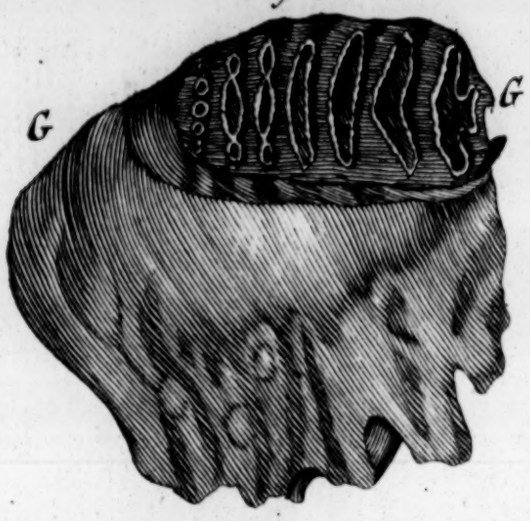

Fig. 26.

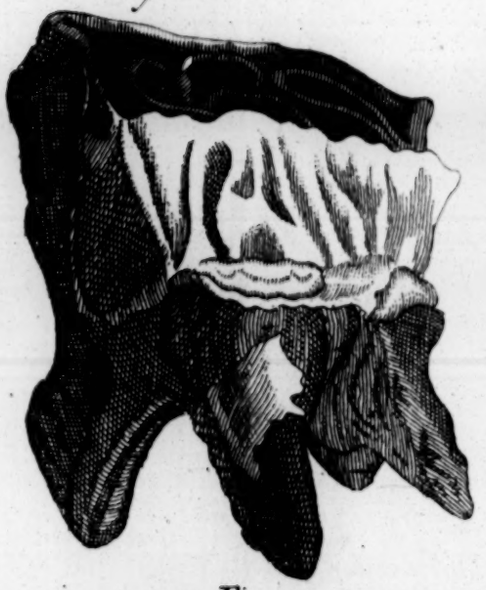

Fig. 35.

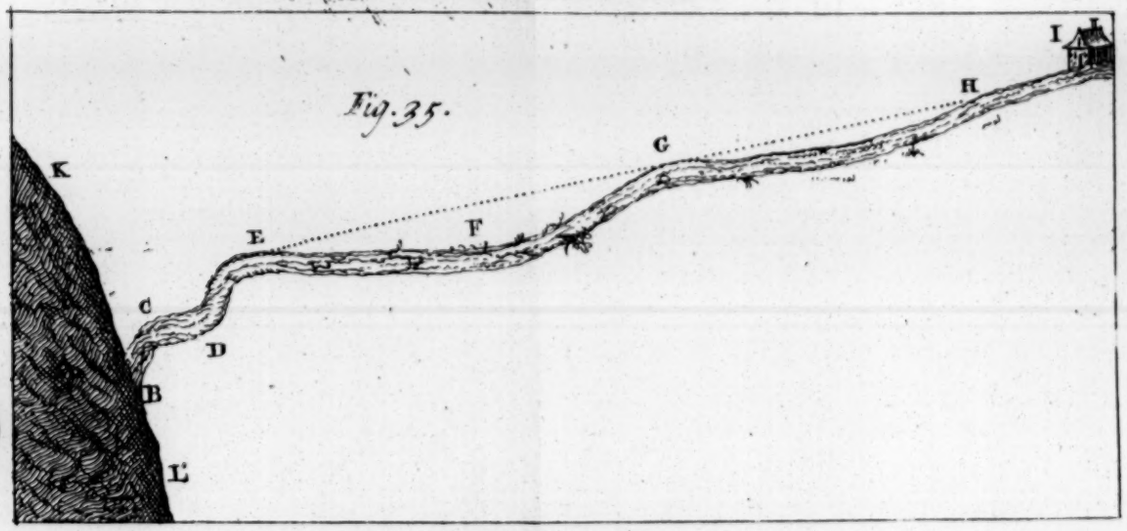

Fig. 29.

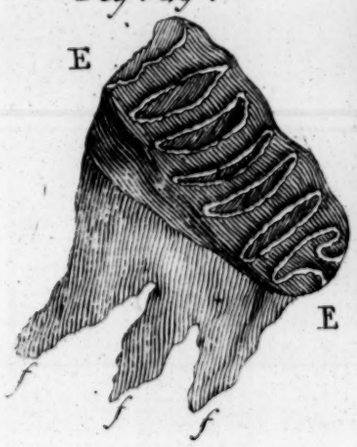

Fig. 36.

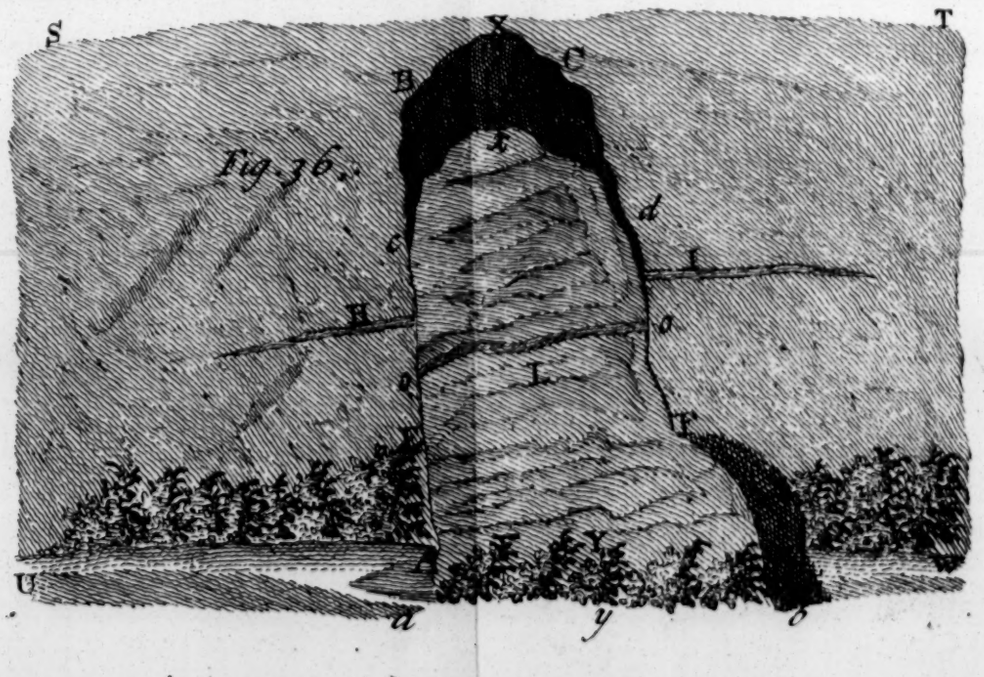

Fig. 31.

Fig. 27.

33 Foot Diameter; whereas the former is not fully 18. Theſe as they ſunk fell acroſs, ſo that obſtructing each other, only the Root of one of them reaches the Bottom, whereas the firſt ſtands Perpendicular.

When the firſt Tree ſunk, it was obſerved that the Water boil'd up in the Hole; but upon the ſinking of the greater Pit, that Water drain'd off into it, from the former, which now continues dry. The depth thereof to the firm Bottom is nine Foot three Inches; and the Tree that ſtands upright in it is three Foot eight Inches in Girt, and its Trunk about eighteen Foot long, half of which is now within the Pit. In the Bottom of the greater Pit there is a Pool of Water about eight Foot Diameter; whoſe Surface is eleven Foot three Inches below the Ground, and the Trees that are in this Pit are much of the ſame length with the other, but ſomewhat ſmaller, the one being in Girt three Foot five Inches, the other but two Foot nine Inches.

The Soil, on which theſe Trees grew, is gravelly; but the Bottom is a Quick-ſand over a Clay, upon which there are Springs, which feed large Ponds adjoining to Sir *Charles Potts*'s Houſe, at about a Quarter of a Mile from theſe Holes.

The Nature of the Soil ſeems to afford us a reaſonable Conjecture at the Cauſe of this odd Accident: The Springs running over the Clay at the Bottom of a Bed of very minute Sand, ſuch as Quickſands uſually are, may reaſonably be ſuppoſed, in many Ages, to have waſh'd away the Sand, and to have thereby excavated a kind of ſubterraneous Lake, over which theſe Trees grew: And the Force of the Winds on their Leaves and Branches, agitating their Roots, may well have looſened the Sand under them, and occaſioned it to fall in, more frequently than elſewhere; whereby in length of Time, the thin Bed of Gravel being only left, it might become unable to ſupport its own Weight, and that of the Trees it bore. That this is not a bare Conjecture, may appear from the boiling up of the Water at firſt in the leſſer Hole, and its ſtanding in the bigger and lower. And if it ſhall be found, that it was a very windy Day, whereon this Accident happen'd, it will much add to the Probability of this Solution.

An Accident not unlike this lately happened in *Fleet-ſtreet*, *London*, by the Defect of the arched Roof of a very deep Common-Sewer. The Earth gradually falling into the Sewer, was carried away by it, ſo as not to obſtruct the Water; and the continual Tremor of the Ground, occaſioned by the conſtant paſſing of Carts and Coaches, by Degrees ſhook down the Earth, ſo as to leave a very great Cavern, the Top whereof at length grew ſo very thin, that one Day a weighty Cart having juſt paſt it, a great ſpace of the Pavement ſunk in, in the middle of the Street, not without hazard to a Coach then driving by.

XVI. 1.] There are Grounds in *Scotland*, which we call *Moſſes*, from whence the Country People dig Turf and Peats. The Surface is cover'd with a Heathy, and (as they call it) Heathery Scurf: Under that

Of the Moſſes *in* Scotland, *&c. by the* Earl *of* Cromertie. n. 330. p. 296.

that Scurf there is a black, moiſt, ſpungy Earth; in ſome Places ſhallower, and in ſome deeper; from 3 or 4 to 7 or 8 Feet deep; and in ſome Places, but not in many, to twice or thrice that Depth. They cut the heathy Scurf with a flat kind of a Spade, which they force Horizontally betwixt the Scurf and the ſpongy Earth, and turn up the Scurf in flat thin Flakes, which they call Turfs. It is over-run with the ſmall Roots of Heath or Heather, and when dried, makes a healthy briſk Fire; but with much Aſhes of a whitiſh, duſkiſh or reddiſh Colour; always the whiter, as it contains more of the woody Roots.

The black ſpongy Earth, which is under the Turf, they cut out in oblong Squares, with Iron Spades made of that Shape, about 8 or 9 Inches long, and about 4 or 5 Inches broad: And as the Men cut them up, the weaker Men, Women and Children, carry them in ſmall Wheelbarrows, ſcattering them on ſome dry Ground, to be dried by Sun and Wind: Some become harder, ſome ſofter, according to the Nature of the Mould, or Earth; the more ſolid, the better Fire; and they are leſs eſteemed, which are more ſpungy. And when they have cut off one Surface, of four or five Inches deep, they proceed downward to another, until at laſt they come to the hard Channel, unleſs they be ſtopped by Water; which alſo they ordinarily remove by making a Channel to ſome Deſcent, if they can; and if they cannot, there the Water ſtagnates.

And in ſuch waſted Pits, where Water hinders to cut the ſpongy Earth to the Bottom; the Pits will be filled up again, in a good Number of Years, with new Ground of ſpungy Earth; which in Progreſs of Time, will come to the Conſiſtence of *Peat-Moſs*, as at firſt, and a Scurfy Heath-Turf will at laſt grow on the Top of it.

I have obſerv'd that Peat-Pits, which have been digged ſince I remember, have grown up again with new Peats; and that ſometimes oftener than once in the ſame Pits; ſome Moſſes growing in ſhorter Time than others. But I have obſerv'd alſo, that when they dig the Peats to the Channel, and in Places where the Water runs off, and doth not ſtagnate, that the Moſſes did not grow, nor renew there again; which moved me to order my Tenants not to cut the Moſſes to the Channel, nor in very large Openings; but rather in ſmaller Pits, that they may grow again more haſtily: And the Event hath anſwer'd my Deſign. But Sir *Robert Adaire* has told me, That without cutting the Moſſes, in the Method of Pits, but by cutting in fully to the Channel, and by laying the heathy Turf, which is cut off the Top of the Moſs, on the Channel, ſo as to cover the Channel over, that in Progreſs of Time a Moſs would grow there again; but not ſo haſtily as in the Pits.

I never obſerved any of theſe Moſſes, which did not ſtand on Plains: Albeit the heathy or heathery Turf, do over-ſpread the Faces and Declivities of the *Scots* Mountains for the moſt Part: There are many Moſſes which ſtand very high on theſe Hills; ſometimes not very far from

from the Top. But the Peat-Moſſes are always in a Plain, though there be Deſcents to them, and Deſcents from them; yet I never obſerved them to ſtand on ſuch a Plain, as the Water might ſtagnate on: And they always have a Deſcent to them, from ſome higher Grounds, whereby Water did deſcend to that Plain; which I take to be the Parent of Peat.

In many of theſe Moſſes, there are found Quantities of Fir and Oak Wood; I never obſerved nor heard of other Woods in them. Theſe are ordinarily found in whole Trees; but the ſmaller Branches are ſeldom found unconſumed: I have ſeen very many, and very great Trees, of both Kinds; but generally ſpeaking, the Oak is always black; the Fir ſometimes whiter, ſometimes redder, as is obſerv'd in all Fir-Woods: But neither Fir nor Oak are found with any Bark upon them. The Fir is generally as freſh and tough, and as fit for any Uſe, as any other old Wood is: Only the Wood of theſe found in Moſſes, has ſo imbibed the Water, that it takes a long Time to dry, and fit it for Uſe, eſpecially the Oak; inſomuch, that when it is put into any ſmall Work, it readily warps and changes its Figure. We never find any of the Oaks ſtanding in the Woods, have that Blackneſs; ſo that I preſume, the Blackneſs accrues from the Water.

There are many Places, where Woods do not now grow; albeit People endeavour to cultivate them; and yet the Moſſes in theſe Places are well ſtored with this kind of under-ground Timber, both Oak and Fir, but eſpecially Fir; ſuch are *Orkney*, the *Lewes* (which are Iſles) *Cathneſs*, *Tarbartneſs*, and the Coaſt of *Buchan*. But yet it would appear, that there have been Woods of Old in theſe Places, or how elſe could they come to theſe Moſſes? For a Proof of which, take the following Account:

In the Year 1651. I being then about 19 Years old, and occaſionally in the Pariſh of *Lochbrun*, paſſing from a Place called *Achadiſcald*, to *Gonnazd*, I went by a very high Hill, which did riſe in a conſtant ſteepneſs from the Sea; only in leſs than half a Mile up from the Sea, there is a Plain about half a Mile round; and from thence the Hill riſes in a conſtant Steepneſs, for more than a Mile in Aſcent. This little Plain was at that Time all covered over with a firm ſtanding Wood, which was ſo very old, that not only the Trees had no green Leaves, but the Bark was totally thrown off; which, the old Countrymen told me, was the univerſal Manner in which Fir-Woods did terminate; and that in 20 or 30 Years after, the Trees would ordinarily caſt themſelves up from the Root; and that they would lie in Heaps, till the People would cut them, and carry them away. They likewiſe ſhew'd me, that the outſide of theſe ſtanding white Trees, and for the Space of one Inch inward, was dead white Timber; but what was within that, was good ſolid Timber, even to the very Pith, and as full of Roſin as it could ſtand in the Wood.

About fifteen Years after, I came the ſame Way, and ſaw not ſo much as a Tree, or Appearance of the Root of any; but in the Place thereof, the whole Bounds, where the Wood had ſtood, was all over a plain green Ground, covered with a plain green Moſs. I aſked the Country People, who were with me, what became of the Wood, and who carried it away? They told me, no Body was at the Pains to carry it away; but that it being all overturn'd from the Roots by Winds, the Trees did lie ſo thick and ſwarving over one another, that the green Moſs (there, in the *Britiſh* Language called *Fog*) had overgrown the whole Timber; which, they ſaid, was occaſion'd by the Moiſture that came down from the high Hill, which was above it, and did ſtagnate upon that Plain; and they ſaid, none could paſs over it, becauſe the Scurf of the *Fog* would not ſupport them. I would needs try it; and accordingly I fell in to the Arm-Pits, but was immediately pull'd up by them. Before the Year 1699, that whole Piece of Ground was turn'd into a common Moſs; where the Country People are digging Turf and Peats. The Peats, as yet, are not of the beſt, and are ſoft and ſpungy, but grow better and better; and as I am inform'd, it does now afford good Peats.

This Matter of Fact, did diſcover the Generation of Moſſes; and whence it is, that many Moſſes are furniſh'd with ſuch Timber.

Theſe Highland Woods are ordinarily ſtored with other Kind of Timber, as Birch, Alder, Aſh, beſides Shrubs, and Thorns; yet we never find any of thoſe Woods remaining in the Moſſes.

What the Reaſon may be, That the Fir and Oak do not now grow in ſeveral Countries, where they are found ſo plentifully in the Moſſes, *Inquirendum eſt.* I ſhall only add, that in a Moſs near the Town of *Elgin* in *Murray*, though there be no River or Water, that runs into the Moſs, yet three or four Feet in the Moſs, there is a ſort of little Shell-Fiſh, reſembling Oyſters, found numerouſly in the very Body of the Peats, and the Fiſh alive within them; though no ſuch Fiſh be found in any Water near to that Moſs, nor in any adjacent River, nor in the ſtagnating Pits that are in that Moſs; but only in the very Subſtance of the Turf: Some of which were ſent to me from the Place, a little before I came from *Scotland.*

——*on the* Same, *by Dr.* Hans Sloan. *ibid.* p. 302.

2.] What the *Earl* of *Cromertie* obſerves in the *Moſſes*, &c. in *Scotland*, I have found to be true alſo in the North of *Ireland.* I have been an Eye-witneſs there, that when the Turf-diggers have come to the Bottom, or firm Ground, by having dug out all the Earth proper to make Turf or Peat, and come to the Clay or other Soil, by draining off the Water, that then there have appeared Roots of Fir-Trees, with their Stumps ſtanding a Foot or two ſtrait upright, and their Branches ſpread out on every Side horizontally on that firm Surface; as if that had been formerly the outward Face of the Ground, and place of their Growth. And I have obſerv'd theſe Roots to be ſometimes ſo near one another,

as

as that their Branches were, as it were, matted, grew over, and gave place to one another, as we every Day ſee in Roots of Trees, where they grow too cloſe. I ſaw once the Body of a Fir-Tree dug up ſo big, as to be judg'd fit for the main Poſt of a Wind-Mill; which was diſcover'd, as many of them (which are not found in digging Turf) are, by the Graſs, which grew over it, being in a very dry Summer of a yellowiſh Colour.

Mr. *de la Pryme* ſent me ſome of the Cones found with this Timber in the great Fens of *Lincolnſhire*, which differed in nothing from thoſe of the *Scotch* Fir, which is plentifully growing in *Scotland* at this Day, and which ſome Years ſince were judged ſo proper by ſome to afford Maſts for the Navy Royal, that ſome Perſons were ſent thither for that purpoſe. But they were not able to bring about what they intended, by reaſon of the Difficulties in the Roads, by which they were to be conveyed to the Sea; which in *Norway* I have heard is in a great Meaſure effected by the Rivers. *Cæſar*, indeed, in his Commentaries, ſays, that the Sorts of Timber in this Iſland, are the ſame as in *France*, *præter fagum & abietem*, except Beach and Fir. The *Earl* of *Cromertie* is a ſufficient Witneſs of his Miſtake, as to one Sort of theſe Trees, and the Beaches in the *Chiltern* Countries near *London*, prove the ſame, as to the other. For the Uſes of this under-ground Timber, beſides thoſe of other Wood, it is ſplit into Pieces, and being lighted, ſupplies the Uſe of Candles. It is alſo made into Ropes, as may be ſeen in the *Muſæum* of the Royal Society, by a long piece of ſuch Rope, bought by the Honourable *Edward Southwell*, Eſq; in *Newry* Market in *Ireland*. The long ſoaking in Water having render'd the Wood of thoſe Trees fit to be made into Ropes. This ſeems to prove, that as the ſoaking of Hemp, Flax, Aloe Leaves, *&c.* in Water, diſſolves the pulpy part, and leaves the fibrous fit for making into Threads and Ropes, ſo the long ſoaking of Trees may make in Length of Time the ſame, or an analogous Change in thoſe of Wood and Timber. I have ſeen what I thought had been Pieces of Wood, not only in Clay-pits, but even in Quarries or Stone-pits, in the Blocks of Stone raiſed out of their *Strata*, or Layers; and have been aſſured by Mr. *Bellers*, that he hath ſeen large Pieces of Wood in the Stone-pits in *Glouceſterſhire*; and alſo that in *Lancaſhire* there is a Moſs, or Turf-Bog, where the black ſpungy Mould, made uſe of for Peats, ſmells very ſtrong of *Bitumen*, or *Petroleum*; of the Oil of which it yields a very great Quantity by Diſtillation. And the late Sir *Edward Hannes* has told me, that near the Lord *Bleſſington*'s Houſe at *Bleſſington* in *Ireland*, there appeared a Light, where the Horſes trampled with their Feet on a certain Space of ſoft Ground: On my Deſire he procured me ſome of this Mould, which agrees exactly in its dark Colour, Lightneſs, *&c.* with Peat Earth. And on Examination of this by a Microſcope, I found the Light proceeded from many ſmall half tranſparent whitiſh live Worms, which lay in it.

The

The Blackneſs of the Oak, comes, in my Opinion, from the vitriolic Juices of the Earth ſoak'd into the Oak, which being aſtringent, is turn'd black by them. Ink is made of Galls, an aſtringent Excreſcence of a ſort of Oak in *Turkey*, made by an Inſect there; and of green Vitriol, which is made of the Pyrites diſſolv'd by Rain-Water, and Iron. Earth of all Sorts, and even human Calculi, and the Aſhes of Vegetables, have in them Particles of Iron, in greater or leſſer Quantities. The Pyrites is alſo very common. The Particles of Iron coming to be diſſolv'd by this Pyrites, Subacid, or other Salts diſſolv'd by Water, or perhaps by Water it ſelf, and carried into theſe Bogs, there faſtens to the Tree, ſoaks into it, and turns it black.

Theſe Particles in ſome River Water, faſtening to the Oak-Timber floated in it, give the ſame a darkiſh Colour, taken Notice of by Mr. *Pepys* in his Naval Memoirs of *England*, p. 71. where we are told by the moſt famous Ship-Builders of *England*, "That the beſt foreign "Plank for the Royal Navy, was brought either from *Dantzick*, *Quinbo-* "*row*, (that is *Koningſberg*) or *Riga*, of the Growth of *Poland* and "*Pruſſia*, or from *Hamburg*; namely, that ſort thereof, which is ſhip- "ped from thence of the Growth of *Bohemia*, diſtinguiſh'd by its Co- "lour, as being much more black than the other, and render'd ſo (as "is ſaid) by its long ſobbing in the Water during its Paſſage thither.

In the Turf Bogs of *Ireland* 14 Foot deep, are found not only the Mouſe-Deers Horns, mentioned in one of the *Tranſactions*, but likewiſe their whole Skeletons, wherein the Bones bear the ſame Proportions to the like Bones of other Deer, as the Horns bear to their Horns. There are alſo found therein, Gold Chains, Pieces of Money, and Roots of Heath, ſeveral *muſci*, and Branches of Trees, ſo ſoft, as to give no Reſiſtance to the Turf-Spade: And I was told, that in cutting Turf in one, they at ſeveral Feet deep cut through what the *Iriſh* call a Ruſkin of Butter (which was a Firkin, or Veſſel, made of the Barks of Trees, uſed by the old *Iriſh* for putting up their Butter.) And I remember, that in digging the wet Dock at *Deptford*, there were found at the Bottom, about nine Foot deep, Graſs Leaves, Hazel-Nuts, and Roots of Trees: And there alſo was found a Piece of Money, as they call'd it; which prov'd to be a Leaden Seal to ſome Bull of Pope *Gregory* the IX*th*, who continued Pope from the Year of our Lord 1227, to 1241.

* Vol. V. From *Leland*, * who wrote in the Reign of King *Henry* VIII we may learn the common Opinion in his Days, of the Cauſe of the Deſtruction of Woods, the growing of Moſſes and Pools; and that, at that Time, in *Wales*, the Senſe of the Inhabitants was, that the under-growing Trees found there, had formerly grown there.

"In

" In theſe Deyes in *Mone* where they digge Turves be founde greate " Rootes of Trees that ſerve Men for Wood. For after the Trees wer " cut doune ſogging Yerth and Moſſe overcoverid them, and now the " ſame Yerth parid away for Turves, the old mayne Rootes appere. Leland's *Itinerary*, *Vol.* V. p. 13.

" Likewiſe at low Water about al the ſhores of both Shores of " *Aberdein* and *Towen Merioneth* appere like Rootes of Trees.

" I ſaw hard by on the lift Honde a great Fenny More, owt of p. 67, " wich the Inhabitantes therabout digge Turfs for Fier, and by the ſame " Fenne is a fair *LLin* cawllid *LLinridde* ii Miles from *Strateflur*.

" *Strateflure* is ſet round about with Montanes not far diſtant, except p. 68. " on the Weſt Parte, wher *Diffrin Tyve* is. Many Hilles therabout " hath bene well woddid, as evidently by old Rotes apperith, but " now in them is almoſt no Woode.

" The Cauſſes be theſe; Firſt the Wood cutt doun was never copi- " ſid, and this hath beene a great Cauſe of Deſtruction of Wood tho- " rough *Wales*. Secondly after cutting doun of Woddys the Gottys " hath ſo bytten the young Spring that it never grew but lyke Shrubbes. " Thirddely Men for the nonys deſtroied the great Woddis that thei " ſhuld not harborow Theves.

" From *Whitchurch* a Mile and a half of I cam by the Pale of the p. 75. " large Parke of *Blakmer* longging to the Erle of *Shreuſbiri*, wherin is a " very fair Place or Loge. The Park hath both redde Dere and falow. " In the Parke (as I hard ſay) be iii. faire Poles, of the wich I ſaw " by the Pale the largeſt called *Blakein*, whereof the Park is namid.

" It is to be ſuppoſid that thes Pooles for the moſt part in Moriſch " Groundes, and lying ſumwhat in low Groundes, dreane the moiſt " Places about them, and ſo having no Place to iſſue owt ſtagne there.

" Sum be likelyhod have begon of Marle Pittes. For the Sandy " Grounde of ſum Parts of *Shropſhire*, and eſpecially of *Cheſtreſhire* " and *Lancaſtreſhire*, will not bere Corne plentifully but it be merlyd.

" From *Blakemers* to *Byklem* in a Foſſe iii. Miles of Sand hard by " *Cholmeley*, firſt I ſaw the great Numbre of Firre-Trees, the wiche " the Inhabitants thereby communely digge up for Fier Wood, but " there did I ſe no Fyrre-Trees grouing. Oftentimes in diggin in this " Moſſe or More for Petes or Turves they finde the hole Trees of the " firſt, ſum ſhort and ſum veri long, without Twike or Bow, lying " ſumtime not a Foote, ſumtime iii. or iiii. Foote depe in the Ground, " but how or when thes Trees cam doune ether be cutting or Wind " Faulle no Manne ther can telle. The Wood of them in Burning " ſavorith of Reſine.

" *Morle* (in *Darbyſhire*) Mr. *Lelandes* Place is buildid ſaving the Fun- p. 79. " dation of Stone ſquarid that riſith within a great Moote a vi. Foote " above the Water, all of Tymbre after the commune ſort of building " of Houſes of the Gentilmen for moſt of *Lancaſtreſhire*. There is as " much Pleaſur of Orchardes of great Varite of Frute and fair made " Walkes and Gardines as ther is in any Place of *Lancaſtreſhire*. He

" brennith

" brennith al Turfes and Petes for the Commoditie of Moſſes and
" Mores at hand. For *Chateley* Moſſe that with breking up of A-
" bundance of Water yn hid did much hurt to Landes thereabout, and
" Rivers with wandring Moſſe and corrupte Water, is within leſs than
" a Mile of *Morle*. And yet by *Morle* as in Hegge Rowes and Grovettes
" is meately good Plenti of Wood, but good Huſbandes keep hit for
" a Jewell.

" Syr *John Holcroftes* Houſe within a Mile or more of *Morle* ſtood in
" jeopardi with fleting of the Moſſe.

" Riding a Mile and more beyond *Morle* I ſaw on the right hond a
" Place nere by of Mr. *Adderton*, and ſo a ii. Miles of to *Lidiate Moſſe*,
" in the right ſide wherof my Gide ſaid that ther were Rootes of Fyrre
" Wood.

" Al *Aunderneſſe* for the moſt parte in time paſt hath been ful of Wood,
" and many of the Moores repleniſhid with hy Fyrre Trees.

Obſervations on the Strata *in* Coal-Mines, *&c. by* J. Strachey, *Eſq*; n. 360. p. 968.

XVII. I have made ſome Obſervations relating to the different *Strata* of Earths and Minerals found in the Coal-Mines of *Mendip* in *Somerſetſhire*. The Draught (*Fig.* 37.) you muſt ſuppoſe the Section of a Coal Country, and to take in about four Miles from the North-Weſt, to the South-Eaſt, and may be applied to the Veins of Coal, as they lie at *Faringdon Gourney*, and likewiſe at *Biſhop-Sutton*, which laſt Place is near *Stowy*, but in the Pariſh of *Chew-Magna* in *Somerſetſhire*. For Diſcovery of Coal they firſt ſearch for the *Crop*, which is really Coal, though very friable and weak, and ſometimes appears to the Day, as they term it, or elſe for the *Cliff*, which is dark or blackiſh Rock, and always keeps its regular Courſe as the Coal does, lying obliquely over it: For all Coal lies ſhelving like the Tyle of a Houſe, not Perpendicular nor Horizontal, unleſs it be broken by a Ridge, which is a parting of Clay, Stone or Rubble; as if the Veins by ſome violent Shock were disjointed and broken, ſo as to let in Rubble, *&c.* between them. The Obliquity or *Pitch*, as they term it, in all the Works hereabout, is about 22 Inches in a Fathom; and when it riſeth to the Land, is called the *Crop*, but in the North *Baſſeting*. In the Works near *Stowy*, and likewiſe at *Faringdon*, it riſeth to the North-Weſt, and pitcheth to the South-Eaſt; but the farther they work to the South-Weſt, the *Pitch* inclines to the South; and *è contra*, when they work towards the North-Eaſt. So likewiſe they obſerve, as they work to the South-Weſt, when they meet with a *Ridge*, it cauſeth the Coal to trap *up*; that is, being cut off by the *Ridge*, they find it over their Heads when they are through a *Ridge:* But on the contrary, when they work through a Ridge to the North-Eaſt, they ſay it *traps down*, that is, they find it under their Feet.

Fig. 37.

Coal is generally dug in Valleys or low Grounds. The Surface in theſe Parts is moſtly a red Soil, which under the firſt or ſecond Spitt degenerates into *Malm* or *Loom*, and often yields a Rock of Reddiſh

Fire-

Fireſtone, till you come to four, five, and many Times to twelve or fourteen Fathom depth, when by Degrees it changeth to a grey, then to a dark or blackiſh Rock, which they call the *Coal Clives*. Theſe always lie ſhelving and regular as the Coal doth. But in theſe Parts they never meet with *Fireſtone* over the Coal, as at *Newcaſtle* and in *Staffordſhire*. Theſe *Clives* vary much in Hardneſs, in ſome Places being little harder than *Malm* or *Loom*, in others ſo hard as that they are forced to ſplit them with Gun-powder: So likewiſe in Colour, the Top inclining to red or grey, but the nearer to Coal the blacker they grow; and whereſoever they meet with them they are ſure to find Coal under them. But to their Diſappointment 'tis not always worth the digging. The firſt or uppermoſt Vein at *Sutton* is called the *Stinking Vein*. It is hard Coal, fit for mechanick Uſes, but of a ſulphurous Smell. About five Fathom and half, ſeldom more than ſeven Fathom, under this lies another Vein, which from certain Lumps of Stone mix'd with it like a *Caput mortuum*, not inflammable, called *Cats-head*, they call the the *Cathead Vein*. About the ſame Depth under this again lies the *Three Coal Vein*, ſo called becauſe it's divided into three different Coals; between the firſt and ſecond Coal is a Stone of a Foot, in ſome Places two Feet thick; but the middle and third Coal ſeem placed looſe on each other, without any Separation of a different Matter. Theſe three Veins before-mentioned are ſometimes work'd in the ſame Pit: But the next Vein which I am going to mention, is generally wrought in a ſeparate Pit; for though it lies the like Depth under the other, the *Cliff* between them is hard and ſubject to Water; wherefore I have repreſented a Pit ſunk through the three upper Veins at *A*, and another ſunk upon the *three Coal Veins* only at *B*; and ſo if they ſink on any of the lower Veins they go more to the North-Weſt. Fig. 37.

Next under the *three Coal Veins* is the *Peaw Vein*, ſo denominated becauſe the Coal is figured with Eyes reſembling a Peacock's Tail, gilt with Gold, which Bird in this Country Dialect is called a *Peaw*. The *Cliff* alſo over this Vein is variegated with *Cockle-ſhells* and *Fern-Branches*, and this is always an Indication of this Vein, which, as I before hinted, is always ſearched for about 15 Fathom to the North-Weſt of the former.

Under this again, between five and ſix Fathom lies the *Smith's Coal Vein*, about a Yard thick; and near the ſame Depth under that again, the *Shelley-Vein*: And under that a Vein of 10 Inches thick, which being little valued, has not been wrought to any Purpoſe.

Some ſay there is alſo another under the laſt, but that has not been proved within the Memory of Man. At *Faringdon* they have the ſame Veins, which, as I am informed, agree in all Parts with thoſe of *Biſhop-Sutton* before-mentioned. But as *Faringdon* lies four Miles South-Eaſt from *Biſhop-Sutton*, ſo, in the regular Courſe, they would lie a Mile and a half deeper than thoſe at *Sutton*. But as in Fact they are dug

near the ſame Depth, it follows there muſt be a *Trap*, or ſeveral *Traps down*, which in all muſt amount to that Depth between the ſaid Works.

Between *Faringdon* and *High Littleton* the ſame Veins ſeem to retain their regular Courſe; but at *Littleton* their undermoſt and deepeſt Vein is the beſt Coal, which at *Faringdon* proves ſmall.

On the other hand, in the Pariſh of *Stanton Drew*, to the North-Eaſt of the Coal-Works at *Sutton* aforeſaid, about a Mile diſtant, and in the true Courſe with thoſe at *Sutton*, the ſame Veins are found again. But here they wind a little, and their Courſe or Drift runs almoſt North, and they dip to the Eaſt; which Winding is attributed to *Ridges*, which the Workmen have met with on both Sides, and have occaſioned them to diſcontinue the Work that way. At *Stanton* they have little of the red Earth or *Malm* on the Surface, but come immediately to an *Iron-Gritt* or *grey Tile Stone*, which is a Fore-runner of the *Coal Clives*; in all other Matters they agree with the Works near *Stowy*.

In the ſame Pariſh of *Stanton-Drew*, a little to the Eaſtward, they have another Coal-work, but the Veins are in all Reſpects different from the former. Their Drift or Courſe is to the Eleven a Clock Sun, as they term it, they *Pitch* to the Five a-Clock Morning, and riſe to land; conſequently to the Five a-Clock Evening Sun. They have ſeveral Veins, but as yet only three are thought worth working. The uppermoſt about three Feet thick ſmall *Lime Coal*. The next is about three Fathom under it, about two Feet and an half thick, fit for culinary Uſes: The undermoſt is about the like Depth under the former, only 10 Inches thick, but good hard Coal.

At *Clutton*, about two Miles from theſe latter, in the ſame Drift, *viz.* almoſt to the South Eaſt and by South, theſe laſt Veins appear again. The Surface here is red, and ſo continues to ten, and ſometimes to fourteen Fathom, and in other Reſpects agree with the laſt mention'd Works at *Stanton-Drew*.

At *Burnet*, *Queen-Charlton*, and *Briſleton*, they have four Veins which Pitch to the North nearly, and conſequently the Drift lies almoſt Eaſt and Weſt. The Surface is red Land generally to the Depth of four or five Fathom. The uppermoſt is from three to ſix Feet thick at *Briſleton*, but leſs at *Charleton* and *Burnet*. The next call'd *Pot-Vein*, is ſix Fathom under the former, eighteen Inches thick, all hard Coal. *Thirdly*, The *Trench Vein*, ſeven Fathom under the other, which is from two Feet and a half to three Feet thick, all ſolid Coal. *Fourthly*, *Rock-Vein*, always diſtinguiſhed by a Rock of Paving-Stone, called *Penant*, lying over it, which Rock is ſometime twenty Feet thick or more, and therefore this Vein is never wrought in the ſame Pit with the former Vein, but about 200 Yards more to the South, or to Land, as they term it. It's computed ſeven Fathom under the former.

This

This is all I can ſay in Relation to the different Veins of Coal and Earth in the Coal-Works in theſe Parts; wherein all agree in the oblique Situation of the Veins; and every Vein hath its *Cliff* or *Clives* lying over it, in the ſame oblique Manner. All of them pitch or riſe about twenty-two Inches in a Fathom, and almoſt all have the ſame *Strata* of Earth, Malm, and Rock over them, but differ in reſpect to their Courſe or Drift, as alſo in Thickneſs, Goodneſs, and Uſe.

Now as Coal is here generally dug in Valleys, ſo the Hills which interfere between the ſeveral Works above-mention'd, ſeem alſo to obſerve a regular Courſe in the *Strata* of Stone and Earth found in their Bowels. For in theſe Hills (I mean thoſe only that are diſperſed between the Coal-Works above-mention'd) we find on the Summits a ſtony Arable mixt with a ſpungy yellowiſh Earth, and Clay; under which are Quarries of *Lyas*, in ſeveral Beds, to about 8 or 10 Foot deep, and ſix Feet under that, through yellowiſh *Loom*, there is a blue Clay inclineable to *Marle*, which is about a Yard thick: Under this, is another Yard of whitiſh *Loom*, and then a deep blue Marle, ſoft, fat, and ſoapy, ſix Foot thick; only at about two Foot thick it is parted by a *Marchaſite* about ſix Inches thick.

It is to be obſerved, that theſe Beds of *Stone* and *Marle*, different from *Coal*, lie all horizontal.

XVIII. 1.] About half a Mile from *Reculver* towards *Herm*, there appear in the Cliff *Strata* of Shells in a greeniſh Sand; they ſeem to be firm, and ſome of them are entire, but when you go to take them from their Beds, they crumble to Powder between your Fingers; but that which is moſt remarkable, is, that in the lower Part of the *Strata*, where the Shells are more thickly diſperſed, there lies ſcatter'd up and down Portions of Trunks, Roots, and Branches of Trees; the Wood is become as black as Coal, and ſo rotten, that large Pieces of it are eaſily broken with one's Fingers. I know not what Depth theſe may lie, the *Strata*'s Surface not appearing above two Foot from the Beach, but I judge it from the Superficies of the Top of the Cliff, about 12 Foot. I ſaw the Stump of one Tree ſtanding upright, broken off about a Foot from the Ground. The Shells were of the White *Conchites*.

Of the Foſſils *of* Reculver *Cliffs*, &c. *by Mr.* S. Gray. n. 368. p. 762.

2.] It is very likely, that the Black Wood, mention'd by Mr. *Gray*, is Oak, which has lain ſo long as to be turn'd of that Colour by the vitriolick Juices of the Earth, in which it has lain; as Galls and a ſolution of Vitriol turn of that Colour. I never ſaw any Oak that had lain any Time in any Kind of Earth, where Water came to ſoak into it, that was not turned of that Colour: And I have ſeen many Trees of Black Wood of great Bigneſs, taken up (as well as leſſer Pieces) and all of it was Oak. It looks at firſt taking up like Ebony, is very ponderous, but as it dries, it ſplits, grows friable, light, and comes to be good for little.

——*A Remark, by Dr.* Hans Sloane, *ibid.*

Some Remarks *on* Foſſils, *by Mr.* E. Lhuyd. n. 291. p. 1566.

XIX. 1.] The State of *Foſſils* is quite different in *Eſſex*, from what it is in *Wales* and *Ireland*. In thoſe Countries the Shells are generally *Cryſtalline*, but in *Eſſex* (and ſometimes about us at *Oxford*) they are *Teſtaceous*: Which Difference is, doubtleſs, to be attributed to the Soil, and particularly to Chalk and Flint, which all thoſe Countries want, excepting a ſmall part (I know not by what Chance of *Diluvian Diſſolution*) got into the *North* part of *Ireland*. But there 'tis remarkable, that their Chalk is abſolutely petrify'd: I mean, whereas the Flints are here imbodied in Chalk, they are there in a Chalk-white *Lime-ſtone*. And as chalky Countries only afford thoſe *Echinitæ* I have ſtil'd *Pileatus*, *Galeatus*, and *Cordatus*; ſo I could never find them in all my Travels, but at that Place; from whence, in the Time of *Paganiſm*, the *Druids* procur'd them, and ſold them amongſt our *Northern Britains* for Stones of miraculous Efficacy againſt Perils by Fire and Water; perſuading the Vulgar they were generated in *Cocks Knees*, as Thouſands in the *High-Lands* believe at this Day. And one Fellow had the Impudence to tell me (finding me a little hard of Belief) that he himſelf had taken one (that his Maſter had ſhew'd me) out of a Cock's Knee with his own Hand.

We were ſurpriz'd here at *Oxford*, to find ſo many *Foſſils*, ſcarce diſtinguiſhable from *Sea Shells*; the Caſe being uſually otherwiſe in thoſe places I ſearched. We have indeed in theſe Parts, one or two *Foſſil Shells* of a *Teſtaceous* Subſtance, but in Colour they recede farther from thoſe of the Sea, than thoſe in *Eſſex*. I find that thoſe in *Eſſex* are ſometimes found imbedded in ſolid Stone; which takes off any Objection ſome might offer, of their being an accidental ſcattering of *Gulls*, *Crows*, &c. on the *Harwich Cliffs*.

Of Harwich *Cliff, and its* Foſſils, *by Mr.* S. Dale. *ibid.* p. 1568.

2.] *Harwich Cliff* is a ſort of *Promontory*, which divides *Orwel Haven* from the *Æſtuarium* contained between that and *Walton Naſe*; it is ſituate on the ſouthern Part of the Town, about a Quarter of a Mile diſtant, or not ſo much, and contains many Acres of Land. The Height of it from the Strand or Beach to the Top, where it's higheſt, is 40 or 50 Foot. At the Bottom of this Cliff, there is a *Stratum* of Clay about a Foot thick, which is ſucceeded by another of Stone for a Foot more; in this *Stratum* of Stone are imbedded divers Shells (though but thinly) as well of the *Turbinate*, as *Bivalve* Kind, and alſo Pieces of Wood and Sticks; over this, are divers *Strata* of blueiſh Clay, about the Height of twenty Foot, or more; this Clay hath *Pyrites* or *Copperas* Stones, ſticking in it, but no Shells, that I could obſerve: Above this, are likewiſe divers *Strata*, which reach to within about two Foot of the Surface, ſome of which are only of fine Sand, other ſmall Stones and Gravel, mixt with Fragments of Shells, and in others ſmall Pebbles are mixt; and it is in ſome of theſe laſt mentioned *Strata*, that the *Foſſil Shells* are imbedded, which lie promiſcuouſly together, I mean the *Bivalve* or *Turbinate*; neither do the

Strata's

Strata's with the Shells obſerve any Order in their lying, being ſometimes higher, and ſometimes lower in the Cliff; and ſometimes 2 or 3 one above another with other *Strata*'s of Sand, Fragments, and Gravel, between. Above all theſe, is a Covering of common ſandy Earth, which is about 2 Foot thick, in which, in ſome places are Veins of a Species of *Oſteocolla*, though more tender than *Oſteocolla Officinarum*, which is brought from *Germany:* This I call *Oſteocolla Anglicana*, it doth incruſt about ſmall Strings, like the Fibres of the Roots of Trees, it's of divers Magnitudes, and ſends forth Branches here and there, but is ſo tender, as not to be gotten out of the Earth in any large pieces. Whether like the *German* it appears above the Earth, I never could diſcover.

Before this Cliff, the Shoar, as far as the ebbing of the Sea would permit my Obſervation, was rudely paved with Stones, divers of which are vein'd with that ſort of Body, which by *Helmont* and other later Naturaliſts, is called *Ludus Paracelſi:* Of theſe Stones the Inhabitants have a Tradition, that they are form'd by the Clay, which tumbling down from the Cliff, and being waſhed by the flowing of the Sea, are in a ſhort Time converted into Stone; and Mr. *Silas Taylor* in his Manuſcript *Collections of Harwich and Dovercourt*, (a Copy of which I have) thus writes concerning it. *The Waſhing of theſe* Cliffs *diſcovers a blueiſh Clay, which tumbling down upon the Shoar, altho' waſhed by the Sea at High water, within a ſhort time turns into Stone: There they may be ſeen, ſome that are new fallen, as ſoft as the Clay in the Cliff; and others that have lain there longer, cruſted over and hard, but if opened or broke, the Clay ſtill ſoft in the middle; others that have lain longeſt petrified to the very heart, and with theſe the* Walls *of the* Town *are for the moſt part built, and the* Streets *generally are pitch'd.* How far this is Matter of Fact, I will not determine, my Stay at *Harwich* being always too ſhort for me to make Obſervations ſo critical as this *Phænomenon* doth deſerve; and although I muſt at the ſame Time own, that many of the Stones are waſhed out from the *Stratum*, at the Bottom of the Cliff; yet I have ſometimes been inclined to Mr. *Taylor*'s Opinion, becauſe he lived long upon the Spot, being *Store-keeper* of the *King's Building-yard* for many Years, and by his *Collections*, &c. ſeems to be a perſon of probity and Learning; and alſo, becauſe divers of the ſaid Stones have Cracks or Chops in them, as Clay and Earth will have by being expoſed to the Sun; and there is yet [*Anno* 1702,] lying upon that Shore a Stone, in which a large pile (perhaps of Oak) ſuch as was formerly made uſe of there, to preſerve the Cliff from the Injuries of the Sea, doth evidently appear to be imbedded; which can owe its Situation to no other Original, than by being preſt into the Superficies of the Clay, while ſoft, and petrifying with it, which being ſquare, takes off an Objection, which ſome might make, had it been round, of its being lodged there in the general Deluge.

I am

I am not inſenſible, that this Manner of Petrification is not only different from the common Methods Nature uſes in that Operation, but alſo is oppos'd by divers learned and ingenious Men; as particularly by the Reverend Mr. *John Morton* in *Oxendon* in *Northamptonſhire*, whoſe Thoughts upon this Subject I ſhall tranſcribe from a Letter of his, to me, dated *Auguſt* 4, 1699.——*At* Harwich, *under the Cliff, upon the Sea-ſhore, there is a* Stratum *of a* Clayey-Stone, *which is cover'd here and there with ragged Stones of a cloſer texture, which was formerly (I conjecture) another entire* Stratum, *but is broken thus by the Tearing of the Waves. The* Clayey-Stone Stratum, *Mr.* Luffkin, *and you, were of opinion, had been formerly a ſofter Subſtance, but was daily petrified by the Sea Water. Having argued a little about it, when turning to the Cliff, I found a* Stratum *there, of the very ſame ſort of* Clayey-Stone, *with that upon the Shore; yet the Sea Water very ſeldom comes up hither, unleſs by Storms, and at Spring-tydes. I broke a little piece off, and ſhew'd it to you, and then you was convinc'd (I think) it was not hardned or petrified by the Sea Water, but in its natural ſtate. And I have often met with juſt ſuch ſort of Stone in many of our* Stone-Pits *here, in Inland Countries. It appears to me, that the Water ſhould have rather ſoftned, than hardned the Stone upon the Shore, tho' by waſhing away the looſer Clayey matter and other Earthy ſtuff, that is ſometimes left upon it at the ebb, it might ſeem to be a ſort of* Petrification, *and occaſion this miſtake.*

As to Petrifactions: *I've only obſerved theſe three ſorts.* 1ſt, A Stony Incruſtation, *upon Sticks and any thing that lyes in the way, in the Petrifying Springs; the Earth in thoſe Waters is uſually intermixt with particles of Stone, that trickle down into it with the Water, and are there detain'd. Of this firſt ſort you have doubtleſs many inſtances in* Eſſex, *and I think there is one at* Harwich *Cliff*; *tho' this in my opinion is not ſo properly call'd a* Petrifaction. 2dly, *The ſecond ſort is that, which is perform'd by the* Permeation *or* Inſinuation *of the finer ſorts of Stony* Particles, *as it is in the caſe of ſome of our Petrifying waters, (I believe) particularly that at* Knareſborough *ſometimes; the Stony particles however of the* Knareſborough *Spring are very fine. And many of the* Foſſil-ſhells *have undergone the ſame fate.* 3dly, *The third, which indeed is a* Petrification, *properly ſo call'd, is often met with on the ſides of* Caves *and* Grotto's, *at* Pooly-hole *in the* Peak, *and in the* Fiſſures, *and* Clefts *of* Mines *and* Quarries. *Of this kind are the ſeveral ſorts of* Fluors, *the* Lap, Stillatitii, Stalagmitæ, &c. *that we meet with in the* Fiſſures, *and* Hiatus's *of the Earth. Theſe are continually growing (as they vulgarly ſay) that is, are receiving an additional increaſe of real and ſolid Stone, as is obſerved in many* Caves *in the* Peak, *&c. This I take to be perform'd in ſuch a manner, as the* Incruſtations *are,* viz. *the particles of Stone are brought along with the Water, as their* Vehicle, *and are depoſited at length upon the ſides of the* Cave *or* Fiſſure, *(this is matter of fact, that there is always a watry Stream, and uſually Water trickling down upon the ſides of thoſe* Caves) *but here, the particles of Stone are extremely minute and fine, and do there-*

by

by naturally concrete and joyn together very cloſe; whereas in our Incruſtations *the Particles of Stone being groſſer, the Stone is rough and coarſe, and friable. And this I leave to your Judgment, if it be not a more reaſonable* Hypotheſis *than that of Dr.* Plot, *in* pag. 33. *of his* Hiſtory of Oxfordſhire, *viz.* That the very Body of the Water is turned into Stone as it drops down from the Rocks. *I know not indeed of any other ſorts of* Petrification, *than theſe I have already mention'd. As to that* Hypotheſis *of the* Tranſmutation *of a* Stratum, e. gr. *of Chalk to Clay, of Coal to common Stone, or the like, I muſt confeſs I never met with any thing in Nature which would countenance it, that is, ſuch a* Tranſmutation *in the Bowels of the Earth. Nor is there any thing that proves it, that ever I have met with in any* Natural Obſervations. *Only ſome will gueſs and fancy ſuch a Thing, but for making it out, I am ſure I am no more able to do it, than to make the* Philoſophers Stone, *whatever they are.*

A late Author is of Opinion, that *this Bed of Stones was the Foundation of the Loamy Cliff, where the Cliff has been waſhed away, or cut: And that they are the Production of a Vitrioline Juice, in Conjunction with the Loam*; as the common Copperas Stones are by the ſame Juice in a *Gravel*, and that the latter were only to be *found* where the *Cliff was gravelly*, and not *where the Loam is.* How far theſe Stones are the Effect of a *Vitrioline Juice*, I will not determine, but this I can affirm, that I have now by me ſome of the *Pyrites*, or common *Copperas Stones*, which I did pick out of the *Clayey Stratum* of this Cliff, in which they may be frequently met with. Nor do I remember at any Time to have obſerved theſe *Stones* to be *inveſted with* either *Gypſum* or *Trichitis*, as the ſame Author affirms, but with the aforeſaid *Ludus Paracelſi*, and ſome other ſorts of *Lap. Stalagmitæ* frequently.

How thoſe Shells or Marine Bodies come to be here poſited, is a Subject, which hath imployed the Heads and Pens of divers learned and ingenious Men. I ſhall not pretend to determine the Controverſy; I ſhall only make ſome Remarks on the poſitive Aſſertion of the aforeſaid Author, concerning the imbedding of theſe *Foſſil Shells* in this Cliff, and the Alteration of the Channel, *viz. That* this *Bed of Shells, which covers the Cliff, was carried thither at the making of the Harbour or clearing of it. For the Harbour or Channel there is artificial, and of no old date, the Current having been formerly on the other ſide of* Languard Fort, *which then ſtood in* Eſſex. Againſt the firſt Part of which, altho' many Reaſons might be given to prove the contrary, I ſhall only mention the following; and as our Author begs the Queſtion, *How elſe could the Shells lye a top* of this Cliff? So I ſhall alſo aſk him, why the ſame *Strata* of Sand, and Fragments of Shells, with the ſame *Foſſils* imbedded, are to be found at *Walton Neſs*, on the other Side of the *Æſtuarium*, which is 5 or 6 Miles broad from *Harwich*, as likewiſe at *Bawdſey* Cliff in *Suffolk*, which is 8 or 9 Miles diſtant, and in other Cliffs on that Shore, where I have met with them. A ſecond Queſtion may here be aſk'd, How it comes to paſs, that none of thoſe *Buccinæ*

cinæ Heteroſtrophæ, (whereof ſuch Plenty of their *Exuviæ* are in all the Cliffs hereabouts) are not now to be found in this Channel, nor the adjacent Seas? (where I have divers Times been a Fiſhing) for I cannot think the clearing this Harbour could have deſtroyed all that Species of Shell-Fiſh, whereof there was then ſuch Plenty; and therefore ſome other Original muſt be allow'd them, than what this Author has aſſign'd. Nor can I allow the *Harbour* here to be *Artificial*, becauſe ſo great a Work as this is, *viz.* the making a Channel two Miles wide, as it is in this Place, would not have been without ſome Record thereof in Hiſtory; and beſides the Earth, *&c.* which muſt ariſe by this Work, muſt conſequently have made a much greater Hill than the Cliff ever was; and another Doubt will from hence ariſe, why the Workmen ſhould bring all the Earth, *&c.* to this ſide the Channel, and not lay ſome thereof on the other, as it's plain they did not. The Ground on which *Landguard Fort* ſtands, as far as *Walton Coleneſs*, which is about three Miles, is only a ſandy Level or Beach, which I believe hath in Time ſubſided there, as may be obſerved at the Mouths of other great Rivers. And as to the Argument, which our Author brings of *Landguard Fort*, being accounted to ſtand in *Eſſex*, to confirm his Hypotheſis of the Change of .this Channel, it will be of no Force with any one, who doth but obſerve, that not only Parts of Pariſhes, but likewiſe of Counties, are often divided from thoſe Pariſhes and Counties to which they belong, and included in others, of which I could give you many Inſtances, *e. gr.* a Part of *Kent* is on the *Eſſex* Side the *Thames*; and in *Oxfordſhire* the Pariſhes of *Shilton* do belong to *Berkſhire*, *Daylesford* to *Warwickſhire*, *Compton* to *Glouceſterſhire*, and *Stratton-Audley* to *Buckinghamſhire*, although all included in the other: And there is a Farm, which doth belong to the Pariſh of *Braintree*, that is ſeparated from it at leaſt two Miles, and many others might be given, but let theſe ſuffice. And to me a probable Reaſon of this Fort's being accounted in *Eſſex*, is, the Sands here ſubſiding, made at firſt, I ſuppoſe, an *Inſula*, which being neareſt to *Eſſex*, was accounted of that County; or 2dly, the Iſland ſo made belonging to none but the Crown, it was at the Pleaſure of the *King's Officers*, to call it of which County they pleaſed. Nor was it *the Gentleman in Cambden*'s Ignorance (whatever this Author ſaith) that made him *mention* theſe Stones *for Petrifactions made by the Sea*; for Mr. *Taylor* in his aforeſaid *Collections* did not omit the Tradition, the Inhabitants of this Town have, about the Alteration of the Mouth of this Haven, which I will tranſcribe in his own Words. *It's generally believed, that* Stoure *did formerly in a ſtraighter Current (than now it doth) diſcharge itſelf into the Sea, about* Hoaſley-bay, *under the High-land of* Walton-Colneſs *and* Felix-Stow *in the County of* Suffolk, *betwixt which and* Landguard-Fort *are (as they are reputed) certain Remains of the old Channel, which the neighbouring Inhabitants ſtill call* Fleets, *retaining at this Day the Tra-*

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dition of the Courſe of the Water, and the Entrance into this Haven to have heretofore been by and through them.

And I am of Opinion that this Tradition is Matter of Fact, having before hinted what Mutations the Mouths of great Rivers daily undergo by the Lodgment of Sands, *&c.* which may be aſſign'd as a better Reaſon for this Alteration than that of our Author, *i. e.* that it was artificial; and the yearly waſhing of the Cliff on the *Harwich* ſide, doth likewiſe add to its Probability; it being a conſtant Obſervation, that where the Sea gaineth on one Side, it loſeth on the other. And that this Level was ſo made, I am confirm'd by the modern Removal of the Fort, more towards the Point, more Sands, I conjecture, being added after the old Fort was built: This Alteration is taken Notice of by the aforeſaid Mr. *Tayler* in theſe Words. *And altho' ſeveral now living pretend to the Remembrance of the building it*; [Landguard-Fort] *yet we find there was an ancienter Fort thereabouts, and called by the ſame Name* [Anno 1553.] *which was not far diſtant from this modern one, a little North of it, where are yet to be ſeen two* Faces *and* Flankers *of a* Baſtion, *the reſt of it being eaten away by the Sea, but in its Place hath left upon the Shoar a long row of Sand Banks.*

The Spring mentioned by Mr. *Gibſon* in his *Engliſh* Edition of *Cambden*, from the aforeſaid Manuſcript of Mr. *Silas Tayler*, is a very ſmall inconſiderable Thing; nor could I obſerve that it did petrify or incruſtate either Pieces of Wood or Sticks; but I have a Piece, which I broke off from a large Pile upon that Shore, which was petrified ſo far as it was drove into the Earth, and the Sea-Water came; and do ſuſpect there yet remains ſome others of the ſame. And of this ſort I believe is that large Piece ſent from hence, which Mr. *Tayler* mentions to be *reſerved in the Repoſitory of the Royal Society.*

I have already taken Notice, that the *Foſſil Shells* are imbedded in a looſe *Stratum* of Sand, Gravel, *&c.* which may ſerve to demonſtrate, that their *Matrix* is not a *Clay bed upon the top* of the Cliff; as likewiſe for another Argument, to evince, that they could not be there ſcattered by *Crows*, *Gulls*, and other Sea Fowls, as well as that ſome of them are likewiſe bedded in Stone at the Bottom of the Cliff; and although ſome few of them may be met with upon the Top of the Cliff, yet it's only where the Earth has been broken by digging Ditches, *&c.*

A *Catalogue* of the *Foſſils*, found by me at this *Cliff.*

1. Buccinum foſſile heteroſtrophum roſtratum lævem maximum *Liſteri* referens. 2. Buccinum foſſile roſtratum maximum *Liſteri* referens. 3. Buccinum foſſile minus ventricoſum, mucrone obtuſo. 4. Buccinum foſſile tenue, minus ponderoſum, ſtriatum & undatum. 5. Buccinum foſſile tenue confragoſum. 6. Buccinum foſſile, ſtriis prominulis marginalibus inſignitum. 7. Buccino-turben foſſile reticulatum minus. 8. Buccino-turben foſſile ſulcatum. 9. Buccino-turben foſſile roſtratum.

tum. 10. Buccino-turben maximum roſtratum foſſile, ſpiris intus ſtriis elatis inſignitis. 11. Cochlea foſſilis maxima umbilicata quinque ſpirarum. 12. Cochlea foſſilis umbilicata, mucrone obtuſo. 13. Nerita parva foſſilis. 14. Turbo foſſilis, ſpiris duabus ſtriis eminentibus inſignitis. 15. Pecten minor foſſilis unica aurita. 16. Auricularia maxima. 17. Pectunculus foſſilis fere circinatus Striis tenuibus, valvis per ginglymon connexis. 18. Pectunculus foſſilis craſſus roſtro acuto ſtriis majoribus. 19. Pectunculus foſſilis faſciis tranſverſis undantibus notatus. 20. Pectunculus vulgaris foſſilis. 21. Pectunculus foſſilis ſtriis majoribus & elatioribus. 22. Pectunculus maximus foſſilis, Liſterianum maximum referens. 23. Pectunculites maximus ſtriis latis. 24. Concha parva foſſilis, faſciis tranſverſis inſignis. 25. Concha longa foſſilis faſciata. 26. Conchites lævis maxima. 27. Conchites parva faſciata. 28. Trigonella minor, ſive vulgatior Anglica *Lithoph. Brit.* 816.

An Account of Land *and* River-Shells, *&c. found under Ground by Mr.* J. Morton. n. 305. p. 2210.

XX. Mr. *Coxe* of *Mears-Aſhby* in *Northamptonſhire* lately diſcover'd ſome *Land* and *River-Shells* under Ground, in a Mooriſh Paſture in *Mears-Aſhby* Field, which Place I went afterwards to view.

It is the more remarkable, becauſe *Land* and *River-Shells* are ſo very rarely met with in digging into the Earth, in Compariſon of *Sea-Shells*, and the Teeth and Bones of *Marine* Animals, which occur almoſt every where and in all Countries. The Reaſon of which is now no longer a Difficulty, theſe Bodies having been ſhewn to be all Remains of the Univerſal Deluge; and the Marine Shells being more ponderous than thoſe of the Lands and Rivers ſunk, and were lodged deeper in the Earth, and ſo were preſerv'd by that Means; whereas the latter being left generally upon the Surface, periſh'd, and are at this Day rarely met with.

Cauſing one to dig into the Mooriſh Ground above-mention'd, we found a ſmall Number of Snail Shells of various kinds buried there. At about a Foot in depth they lay very thick; and ſinking ſtill downwards, the Number rather encreaſed till we came to the depth of about three Feet. 'Twas troubleſome to ſink deeper on Purpoſe; but we made Tryals for a conſiderable Extent of Ground, *viz.* about 250 Feet in length, and 130 in breadth. Beſides, the ſame Shells were caſt up in ſeveral Places, at Diſtance, by Moles. What we principally obſerved in this Search, was, 1. A moiſt Mooriſh black Earth, in ſome Places a Foot and a half, in others ſomewhat above two Feet in Thickneſs. The lower half of it is blacker and denſer than the upper half, of a bituminous Nature, and has all the Characters of Peat-Earth. Beſides Shells we found Stalks and Leaves of Graſs, and alſo of many kinds of other Vegetables, repoſited as uſual in like Bituminous Moors in other Parts of this Iſland. 2. White Earth; ſo at firſt we call'd it: But upon cloſer Inſpection it appeared to be little more than Hay half waſted. So deep as we ſunk into it, we found it every where copiouſly interſpers'd with Shells.

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The finding theſe Shells under Ground, made it very reaſonable to enquire, whether there were any of the like at this Time, living upon the Surface. I diligently ſearch'd this Place, but could not meet with any live ones of any Kind whatever, there.

The Foſſil Shells were ſome the *Exuviæ* of Land-Snails, the reſt of River or Freſh-water Snails: Of the former, there were the three following Kinds: 1. A ſmall *Buccinum*, of five Wreaths, the *Buccinum exiguum quinque anfractuum, Tit.* 7. *Liſt. in Tractat. de Cochleis Terreſtr. Angl.* A Kind obſerv'd by Dr. *Liſter* to live in Moſs upon old Garden Walls at *Eſtrope* in *Lincolnſhire*; by my ſelf at the Moſſy Roots of old Trees in many of the *Northamptonſhire* Woods, as alſo amongſt Moſs upon the boggy Sides of ſeveral ſtanding Springs.

2. A *Cochlea* of the compreſſed Kind, but not ſo much compreſſed as ſome of them are. It has ſix Wreaths, and a ſmall circular *Sinus* in the Center. This, if it is not the *Cochlea umbilicata, &c.* N. 79. *Liſt. Hiſt. Conchil. Lib.* 1. has not hitherto been mention'd by any Writer; though common enough in the Woods in *Northamptonſhire*: I found a greater Number of them, for the Compaſs of Ground, inclos'd in the Earth, than ever I have done in any of the Places where they naturally breed.

3. The *Cochlea citrina, Tit.* 3. *Liſt. de Cochl. Terreſt. Ang.* The Common ſtrip'd Snail Shell. But moſt of theſe in the Moor, are white, of the Colour of the Shells that have been a long Time dead. In ſome I ſaw faint Foot-ſteps of their former Stripes. Moſt of the Shells of this Kind, were lodg'd about 4 Foot deep.

We met with only two different Kinds of River Shells: 1. A Perewinkle Shell of three Wreaths, generally leſs than the *Buccinum trium Spirar. Tit.* 24. *Liſt. de Cochleis Fluviatil. Ang.* There was a greater Number of theſe buried in the Moor, than of any of the former Kinds.

2. A Perewinkle Shell of five Wreaths, much ſmaller, and more prominent than thoſe of the *Buccinum longum ſex Spirarum, Tit.* 21. *Liſt. de Coch. Fluviat.* 'Tis otherwiſe very like that *Buccinum* in the Faſhion of its Wreaths. It has not yet been deſcrib'd by any Author. We find the Kind now living in one of the *Northamptonſhire* Brooks, call'd the *Iſe*.

The mooriſh Ground, wherein theſe Shells were buried, extends from near the Top to very near the Foot of a ſmall Hill. Above the Moor, upon the Top, and at the Brow of the Hill, is a ſandy Soil of a reddiſh Colour. The whole Face of the Moor is plain and even, conformable to the reſt of the Hill not thus moory of the ſame Declination with it, and appears to be in a natural and undiſturbed State, as much ſo as any of the Slades in the neighbouring Fields; excepting that 3 or 4 Trenches have been cut through it of late.

'Tis evident, that theſe Shells were left at the Deluge, when thoſe from Sea were alſo repoſited at Land; and not buried ſince by De-

terrations from the Ground above: For then the upper parts of the Moor muſt have been cover'd with a reddiſh Sand, ſuch as the Ground is, for the main, compos'd of: But nothing like that appears near the Shells in this Moor. Beſides, here are dug up ſeveral Shells, that in all Likelihood never bred here, but are Inhabitants of a different Soil; particularly the ſtriped Snail-ſhell: For theſe Animals have peculiar Soils, and affect particular Regions.

An Account of the Skeleton *of a large* Animal *impreſs'd in* Stone, *by Dr.* W. Stukeley. n. 360. p. 936.

XXI. At the Reverend Mr. *South*'s at *Elſton* near *Newark* in *Nottinghamſhire*, was lately diſcover'd a Skeleton, almoſt entire, of a large Animal (which I have procur'd for the *Repoſitory* of the *Royal Society*) impreſs'd in a very hard Stone; it had lain Time out of Mind, at the ſide of a Well, where it had ſerv'd for a Landing-place to thoſe that drew Water; but upon removal, the under ſide exhibited this unuſual Form.

The Stone itſelf is a blue Clay-ſtone, the ſame as (and undoubtedly came from) the neighbouring Quarries of *Fulbeck*, or thereabouts, upon the Weſtern Cliff of the long Tract of Hills, extending quite through the adjacent County of *Lincoln*.

It is a great Pity, that ſo conſiderable a Rarity ſhould be maim'd and imperfect; but where the remaining part of the Stone is, which contain'd the upper Part and Continuation of the Skeleton, or that which was the other ſide, and tally'd with it, is utterly unknown. This Skeleton at firſt was taken to be *Human*, which upon View I am perſuaded it cannot be; it ſeems rather to be that of a *Crocodile* or *Porpeſs*. Fig. 38. There are ſixteen *Vertebræ* of the Back and Loins, very plain and diſtinct, with their Proceſſes and intermediate Cartilages. Nine whole or partial Ribs of the Left-ſide, the *Os Sacrum*, *Ilium in ſitu*, and two Thigh Bones diſplac'd a little, the Beginnings of the *Tibia* and *Fibula* of the Right Leg; on one Corner there ſeem to be the *Veſtigia* of a Foot, with four of the five Toes, and a little way off, an entire Toe, now left perfect in the Stone: There are no leſs than eleven Joints of the Tail, and the Cartilages between them of a white Colour, diſtinguiſhable from the reſt. We ſhould impoſe upon our Senſes, to queſtion whether theſe be the real Reliques of an Animal; for the very Bones themſelves are now to be ſeen as plainly, as if preſerv'd in an *Egyptian* Mummy; a very little while ago, the Society had a Draught of a Crocodile, though a ſmall one, found after the like Manner, inclos'd in Stone, from a Quarry in the Mountains of *Upper Germany*. I ſuppoſe the ſame Reaſon accounts for both, and all the reſt of theſe Kinds of Foſſils; and it is an ocular Evidence, and a great Confirmation of what I laid before the *Royal Society*, in a late Diſcourſe, where I hinted at a Solution of ſome obvious and remarkable Phænomena, in the external Face of the Globe, conſequent to its Formation, as ſet forth in the *Moſaic* Account; and of ſome Changes it ſuffer'd at the univerſal *Cataclyſm*, and Proofs of that great *Cataſtrophe* of the Animal and Vegetable

getable World in Plants, Shells, and Parts of living Creatures found in Rocks and Quarries.

It is remarkable, that all the Stone Pits about the Country whence this came, abound with prodigious Quantities of Shells, and the like, and the greateſt Part of the Subſtance of the Stone is a Compoſition of them. There are many Accounts of them in the *Tranſactions*, and this Stone has many Shells of different Kinds in it. Sir *Hans Sloane* has a Fiſh Skeleton, amongſt his immenſe Treaſure of Curioſities, found near this Place, given by the Duke of *Rutland*. If we look upon a Map of the Country, and obſerve the *Lincolnſhire Alps*, how they run fifty Miles North and South, and on the Weſt-ſide are ſteep and rocky, we may ſee the Reaſon why theſe Quarries ſhould be ſo ſtuft with them; for it is juſt to conceive, that upon retiring of the Waters of the Deluge from the Superficies of this Country, into the Eaſtern Seas, theſe heavy Bodies met a full Stop, and were intercepted by this Cliff, which has retained ſuch vaſt Quantities of them ever ſince: Whilſt thoſe which fell upon common Mould are moſtly rotten, and now loſt.

Sir *Iſaac Newton*'s Doctrine of the Attraction of the Particles of Matter, according to the Quantity of its Solidity, Proximity, and Surface; eſpecially that it is infinitely greater in the Point of Contact, upon which depends its Coheſion and all the Varieties of Phyſical Action, will eaſily direct us to a Notion of Petrifaction. We learn how a proper Degree of Heat or Cold, Moiſture, Motion, Reſt and Time, promote this Principle, from the common Experiments of Chryſtallization and Freezing, even before the Fire, and in many chymical Mixtures. Whence we cannot be ignorant of Stone growing in the Quarries gradually, not by any fancied Vegetation, though there is ſomething like it in Corals, but generally by Appoſition of Parts to Parts, as is notorious in the *Fluors* of ſubterraneous Grots and Caverns. So that we have no Reaſon to doubt but what was Clay, Sand, or Earth 3000 Years ago, may now be Stone or Marble, according to the Proportion of Concurrence of ſuch mentioned Cauſes. This will perſuade us, that the now barren and rocky plains of the Countries of *Syria*, *India*, and *Arabia*, are owing to natural Cauſes, as well as an immediate Curſe of God, for the Diſobedience of its ancient poſſeſſors his peculiar people; becauſe the ſame is obſervable of the famous Countries of *Greece* and *Africa*, warm Regions ſo renowned for Fertility in ancient Authors. Wherefore there may be ſome Likelihood in the Opinion of thoſe who think that in many Ages the whole Face of the Globe may become one great Rock. Dr. *Plott*, in his Natural Hiſtory of *Oxfordſhire*, gives an Account of a *Tumulus*, now a perfect Mount of Stone; and upon St. *Vincent*'s Rock near *Briſtol*, are fortifications now become ſolid Cliff. I remember, about ſix Years ago, Mr. *Ralph Widdrington*, Brother to the Earl of that Name, ſhew'd me many human Bones taken from whole Skeletons, with *Britiſh* Beads, Chains, Iron Rings,

Rings, Braſs Bitts of Bridles, and the like, which were dug up in a Quarry, near the Seat of the Family, at *Blankney*, *Lincolnſhire*; which very probably was plain Mould, when theſe old Corpſes of the *Britons* were interr'd; and ſince then I ſaw many human Bones and Armour, with *Roman* Coins, *Fibulæ*, &c. found in a Stone Pit in the Park at *Hunſtanton*, *Norfolk*; belonging to Sir *Nicholas L'Eſtrange*, in whoſe Cuſtody they now are, which were conjectured to have been buried in Earth after a Battle. From whence we may judge it a vulgar Miſtake, when in the Ruins of the old Caſtles and Walls we admire the Tenacity of the Mortar, and are apt to praiſe our Anceſtors, for an Art which we ſuppoſe now loſt; when doubtleſs the Strength of the Cement is owing to the Length of Time: And in future Ages our modern Buildings may obtain the ſame Judgment.

From all which Inſtances, I infer the ancient State of theſe Cliffs, where this Skeleton was, and Shells are daily found, intimately mixt in the Subſtance of the Stone, to have been formerly of a ſofter Conſiſtence, capable of admitting them into its Bowels, and to have immur'd them as part of it ſelf; and that Earth which is now manageable by the Plough, may poſſibly in Time aſſume the ſame Denſity, at leaſt very little below the Surface; for in this very Cliff the upper *Strata* are yet Clay, growing harder as deeper. What Creature this has been, for want of a Natural Hiſtory of Skeletons, we cannot poſitively determine; but generally find the like to be amphibious or marine Animals. Why ſuch, rather than many others, ſhould chance to be thus entombed, may be thought, becauſe they were able, much longer than Terreſtrial Animals, to live in that World of Waters, even till they began to abate and fall away into their deſtin'd Receptacles; ſo that while the Bodies of the reſt ſoon periſhing, were corrupted, and their Bones ſeparated and diſperſed much earlier; this Skeleton, with others of its like, fell entire into the Fiſſures of this Bed of Clay, which has ſince turned into Stone, and made this noble Monument and pregnant Token of that general Inundation.

Of Chryſtal, *&c. by Mr.* R. Thoreſby. n. 277. p. 1071.

XXII. Dr. *J. Cay* preſented me with a *Chryſtal* (and other Natural Curioſities) which he brought from *Milan:* I ſhall give you his Deſcription of it, firſt premiſing his Arguments upon a ſort of *Spar* within a *Flint*. That within the Flint (ſays he) ſeems to differ from the reſt of its Subſtance, and ſomewhat to reſemble *Spar*: Though after all, *Spar* being nothing elſe but a *Chryſtalline* ſort of *Lime-ſtone*, it differs not from *Flint* in Reality, but only in Appearance, *i. e.* in the Manner of *Concretion:* Though if the encloſed Matter had in its Nature differed from the reſt of the Stone, the Thing had not been very uncommon; it being uſual enough, for Stones (eſpecially thoſe of a Globular or Oval Form) to have Coat upon Coat, and thoſe Coats ſometimes very different one from another, ſome of them ſoft, ſome hard; nay, ſometimes, after a long Space of Time, one of theſe Coats will ſhrink from another

another, after the Manner of a Kernel, when the Shell grows dry; and then, if the encloſed Subſtance continue ſoft and marly, they call that Stone *Geodes*; but if ſtony, it makes one of thoſe rattling Stones that are known by the Name of the *Ætites* or Eagle-Stone.

To confirm what I have advanced, many Inſtances might be brought, that it is no unuſual Thing for Stones to encloſe Subſtances of a very different Nature from themſelves: The *Shells* which I have ſeen in *Suſſex* Marble is one Proof; and the *Stones* found in our *Coal-Pits*, and known among the Workmen by the Name of *Cat-heads*, may ſerve for another; they are found in a particular *Stratum* near the Coal, and encloſe a *Fern*, or ſometimes *Polipody Leaf* in the middle of them; and for that Reaſon being ſtruck with a Hammer very readily break there: I think they are a ſort of *Iron-Stone*, a-kin to that which they call in *Staffordſhire Ballmine*; and Dr. *Liſter*, *Minera ferri Pilæformis*; they have it upon the Weſtern Coaſts near *Whitehaven*, and call it there by the Name of *Cat-ſcamps*: I have ſeen it too upon the *Yorkſhire* Coaſts in *Robin-Hood*'s Bay: It may be called *Lapis Mineræ ferri*, *Pilæformi ſimilis*, *in cujus Meditullio unum vel plura Filicis folia repræſentantur.* I have Specimens of both Sorts. And as an Inſtance, that *one and the ſame Piece of Rock does not always ſhoot into Stone at one and the ſame Time*, *but firſt one Part of it*, *and then another*, and they too not after the ſame regular Manner: I have Piece of *Rock Chryſtal*, where one may eaſily obſerve the *Modus Concreſcendi*, in the Middle to have differed from that of the outſide; nay ſometimes I have ſeen in the Middle of ſome tranſparent Stones, a ſmall Drop that never would take the ſolid Form of the reſt of the Stone at all.

I have received from Dr. *Cay* a Piece of an *Iron Bolt* (two Inches long) found in a *Stone* Quarry, now returned into *Iron Ore* again; this being a Property that Iron has, and no other Metal, as Dr. *Liſter* obſerves in his Journey to *Paris*. Iron.

I have received from *Sweden* a Piece of *Copper Ore* regularly ſhot into an *Octoedrous* Form: It has eight ſolid Triangles, and conſequently ſix angular Points; and is of the Bigneſs and Figure of the Draught, (*Fig.* 46.) it came from the Copper Groves at *Fallum*, where very many of the ſame Form were then found. Copper-Ore. Fig. 46.

XXIII. I ſhall give an Account of my Obſervations on ſeveral natural ſolid *Noctiluca*'s, not hitherto by any, as I know, taken Notice of; (I think I may be well aſſured ſome of the *Phænomena* never were:) and ſhall firſt ſpeak a little concerning the artificial *Phoſphorus*, which, is a Subject I have made a great Number of Experiments about, whereby I was naturally led to the following Remarks. *Of the* Luminous *Qualities of* Amber, Diamonds, Gum-Lac, *by Dr.* Wall. n. 314. p. 69.

Many Years ago (about the Year 1680.) Mr. *Boyle* communicated to me his Way of making the *Phoſphorus* with Urine: But his Chymiſt, Mr. *Bilgar*, was forc'd to evaporate a prodigious Quantity of Urine, to get a very little of the *Phoſphorus*; which induced me to think for ſome other

Matter

Matter, from which more might be made than from Urine: It being then a very hot Summer, I caus'd a Piece of the dry'd Matter in the Fields, where they empty the Houſes of Office, to be digg'd up, in which, when broken in the Dark, a great Number of ſmall Particles of *Phoſphorus* appear'd; but of this could be made little or no *Phoſphorus*, till another Matter was added to it in Diſtillation.

Reflecting on the artificial *Phoſphorus*, I conſidered whether there might not be, *in rerum naturâ*, other natural ones, beſides thoſe that Mr. *Boyle* and ſome others have given an Account of.

Human Urine and Dung do plentifully abound with an *Oleoſum* and common Salt, ſo that I take the *artificial Phoſphorus* to be nothing elſe but that Animal *Oleoſum*, coagulated with the Mineral Acid of Spirit of Salt, which *Coagulum* is preſerved, and not diſſolved in Water, but accended by Air.

Theſe Conſiderations made me conjecture that *Amber*, (which I take to be a Mineral *Oleoſum* coagulated with a Mineral Volatile Acid) might be a natural *Phoſphorus*, ſo I fell to make many Experiments upon it; and at laſt found, that by gently rubbing a well poliſh'd Piece of Amber with my Hand in the Dark, which was the Head of my Cane, it produced a Light; whereupon I got a pretty large Piece of Amber, which I cauſed to be made long and taper, and drawing it gently through my Hand, being very dry, it afforded a conſiderable Light. I then uſed many kinds of ſoft Animal Subſtances, and found none did ſo well as that of Wool. And now new *Phænomena* offered themſelves; for upon drawing the Piece of Amber ſwiftly thro' the Woollen Cloth, and ſqueezing it pretty hard with my Hand, a prodigious Number of little Cracklings were heard, and every one of thoſe produced a little Flaſh of Light, but when the Amber was drawn gently and ſlightly through the Cloth, it produced a Light, but no Crackling; but by holding one's Finger at a little Diſtance from the Amber, a large Crackling is produced, with a great Flaſh of Light ſucceeding it, and, what to me is very ſurprizing, upon its Eruption it ſtrikes the Finger very ſenſibly, whereſoever apply'd, with a Puſh or Puff like Wind. The Crackling is full as loud as that of Charcoal on Fire; nay, five or ſix Cracklings, or more, according to the Quickneſs of placing the Finger, have been produced from one ſingle Friction, Light always ſucceeding each of them. Now I make no Queſtion, but upon uſing a longer and larger Piece of Amber, both the Cracklings and Light would be much greater, becauſe I never yet found any Crackling from the Head of my Cane, although 'tis a pretty large one; and it ſeems, in ſome Degree, to repreſent Thunder and Lightning; but what to me is more ſtrange, is, that though upon Friction with Wool in the Day-Time, the Cracklings ſeem to be full as many, and as large, yet by all the Trials I have made, very little Light appears, though in the darkeſt Room; and the beſt Time of making theſe Experiments, is when the

Sun

Sun is 18 Degrees below the Horizon; and when the Sun is ſo, though the Moon ſhines never ſo bright, the Light is the ſame as in the darkeſt Room, which makes me chuſe to call it a *Noctiluca*.

As the Artificial *Phoſphorus* led me to that of Amber, ſo Amber directed me to that of a *Diamond*, from its being Electral as well as the other; which is alſo a Natural *Phoſphorus*, or rather a *Noctiluca*, exceeding all others, and may, without any Exception, be called a Mineral *Phoſphorus*, it being, as I think, the moſt pure of all *Oleoſums*, coagulated with a Mineral *Acidum*; and if in the Diſcovery of this I have not oblig'd the Learned, I am in Hopes I ſhall all thoſe who deal in Diamonds: Mr. *Boyle* has given the World an Account, at the latter End of his Book of *Colours*, of Mr. *Clayton*'s Diamond, and afterwards ſays, that ſome Diamonds would not ſhine in the Dark: but if any one elſe has ſince then made a Diſcovery, that all Diamonds would give Light in the Dark, they have been very unkind to the World in not letting them know it, becauſe I am well aſſured that a great many People have been, but too often, cheated with them, which I hope to prevent. I have now by me a yellow Diamond, which I have ſhewn to a great many Jewellers and others, and but a few of them will allow it to be a Diamond; but by as many Trials as I have made, I think my Way of diſtinguiſhing Diamonds is ſo certain, that none need fear to affirm them to be ſo.

A Diamond, by an eaſy ſlight Friction in the Dark, with any ſoft animal Subſtance, as the Finger, Woollen, Silk, *&c.* appears in its whole Body to be Luminous; nay, if you keep rubbing for a little while, and then expoſe it to the Eye, 'twill remain ſo for ſome little Time: But if the Sun be 18 Degrees below the Horizon, if any one holds up a Piece of Bays or Flannel ſtretch'd tight between both Hands, at ſome Diſtance from the Eye, and another rubs the Bays or Flannel with a Diamond ſwiftly and pretty hard on the other ſide of it, the Light to the Eye of him that holds it, ſeems much more pleaſant and perfect, than any other Way I have yet try'd. But what to me ſeems more ſurpriſing is, that a Diamond being expos'd to the open Air, in View of the Sky, gives almoſt the ſame Light of itſelf without rubbing, as if rubb'd in a dark Room; and if in the open Air you put your Hand or any Thing elſe a little over it, to hinder its Communication with the Sky, it gives no Light: I have try'd all or moſt of the precious Stones, but could find no ſuch *Phænomenon* in any of them. All theſe Experiments were made at the latter End of *May*, and Beginning of *June*, and therefore, I cannot pretend to account for the *Phænomena* that may attend Experiments made while the Sun is on the other Side of the *Equator*.

I am well assur'd, that all or most of the Bodies which have an Electricity yield Light; for in my Opinion 'tis the Light that is in them, which is the Cause of their being Electral; yet this Electricity never shews itself without Friction; if you rub any Body that has an Electricity, and apply it near to some light Bodies, as particularly very thin Slices of Cork, 'twill put them into a great Agitation, and make them seem to the Eye, as hanging at the Body by a fine Hair.

I forbear speaking of *Jet*, which seems to me to be a black Amber, having most of the Properties of Amber, but not so perfect and pure.

I must not forget to speak of another Substance, not hitherto by any (as I know) taken Notice of to be endu'd with a luminous Quality, which is also another natural *Phosphorus*, or *Noctiluca*, and that is *Gum Lac*, and also red Sealing-Wax, which is made with *Gum Lac* and *Cinnabar*, the *Cinnabar* no Way impeding, but rather promoting its luminous Quality; for I caused long taper Rolls to be made up of *Lac* alone, and of pure red Sealing-Wax, both being well polish'd: The Sealing-Wax upon Friction, seems to me to emit its Crackling and Light sooner than the *Lac*, which I impute to the *Cinnabar*'s constringing its Parts, tho' I think *Lac*, *per se*, has the greatest Electricity, both having all or most of the Properties of Amber; and by all the Tryals I have hitherto made of *Lac* and Sealing Wax, I find that though the Cracklings are as plentiful in the Day-time, as when the Sun is down, yet in the darkest Places I could discover but a little Appearance of Light, so that this deserves the Name of a *Noctiluca* or *Phosphorus*, as well as the others; it being no other than a vegetable *Oleosum*, coagulated with an Animal Volatile *Acidum*. I don't know in the Animal Kingdom any Thing but Pismires, that affords a Volatile Acid, and in the *East-Indies* there's a large kind of them that live on the Sap of certain Plants, affording both a Gum and a Colour, which Sap passing through the Body of those Insects or Animals, is by their Acid Spirit converted into an Animal Nature; which is the Reason, that with the Colour extracted from *Gum-Lac* (which *Gum Lac* is nothing else but the Excrements of these Insects or Animals) almost as good, and full as lasting, Colours are made as from *Cochineal:* I am the more confirmed herein, because I know of an Artificial Way of converting Vegetable Colours into an Animal Nature very much like this, by which the Colours are made more pleasant and permanent. After the same Manner the remaining Gum, which is an *Oleosum*, being digested and passing through the Bodies of those Insects or Animals, is by their Volatile Acid converted into a Vegetable Animal *Phosphorus* or *Noctiluca*; the Artificial *Phosphorus* is a Mineral Animal *Phosphorus*, whereas I take the others to be altogether Mineral.

XXIV.

XXIV. *Avicenna* ſcribit, *Ambarum*, fungorum in rupibus ac arboribus more in Maris Alveo, generari. *Alii* non ſecus, ac in terra, fungos ſuper marinas enaſci aquas. *Hieronymus* à *Huerta* in Annotationibus Traductionis *Plinii*, certas aſſerit eſſe algas, ſeu excrementitias maſſas ſuper Maris aquas, in forma fungorum enatas, quæ recenter collectæ inodoræ, nec fragrantiam ſpirant, donec curentur: Nec bituminis genus, aut Balænæ eſſe ſemen, eò quod iſta ſemel indurata, nequaquam ut *Legitimum Ambarum* rarefieri queant. *Jonatius Alzina* in Hiſt. *Biſai*, eò quod aliquando & Balæna evomatur, in ea nonnunquam inveniatur, & ab *Indis* Taeſa bonganſiſo, *i. e.* excrementum Balænæ *vocetur*: *Ambari* materiam algas, ſeu plantas eſſe marinas reſinoſas, aut reſinam maris in fundo creſcentium arborum, aut ex jam putridis algis, ac maris recrementis enatam mucilaginem a Balænis depaſtam conjecturatur. *Nicolaus Monardes*, bituminis genus ex fontibus in alto mari manans, quod & *Guili* du *Wallig.* defendit. *Alii*, & *Simon Sethi* in diverſis ſcaturire locis, & eſſe ejus fontes ut bituminis. *Garcias ob Orta* opinatur veriſimiliter Inſulas, aut terras ſimilis c. *Ambaro* formæ inveniri. *Ferd. Lopez. Caſtanneda* Avium *Inſulæ* de *Maldiva*, quæ herbis paſcuntur odoriferis, eſſe ſtercus. *Car. Cluſio* narravit *Servatius Marel* eſſe recrementa in veræ balænæ ventriculo congeſta ex materia viſcoſa. *Alii*, ex Piſce *Azelo* devoratum proximè dorſi ſpinam eximi. *Ferd. Caſtrillo* liquorem piſcium collectum circa eorum œſophagum, ut *Braſilia* reduces teſtantur. *Fran. Combes* Iolo *Incolas* excrementum eſſe piſcis *Gadiamina*, qui differens, & balæna major eſt, narrare refert. * *Alii* ex fructu quodam odorato a balæna devorato fieri volunt. *Alii* ſperma, *alii* hepar, *alii* cum Sinis (qui illuc *Hay ano ſay*, vocant, *i. e.* preſervans veſtimenta â Tinea) excrementum balænæ, nonnulli maris ſpumam eſſe contendunt. *Cteſias* apud *Ariſt.* Semen *Elephantis*. *Fuchſius* factitium ex ligno aloes, Zibetho, Styrace & Ladano. Indi *Lutai* apud *Combes*, ex arboris marinæ, maximæ & aromaticæ muſcoſis, viſcoſiſve fieri adherentiis aut accrementis. *Alii*, & hi prudentiores, ex ejuſdem arboris reſina, cui opinioni & ipſe auctor accedit, adjiciendo *Ambarum crudum* odoris eſſe expers, & adeo *Pilis* (Amygdalo-piſtacea eſt) reſinæ ſimile eſt, & facile inflammabile; ut multi incauti decepti avaritiæ ſuæ debitas luerint pœnas. *Hieronymus à Huerta* opinionem eſſe quorundam, *Ambarum* reſinam l. gummi eſſe arborum, aut Pini reſinam. *Thomas Bartholinus* in Actis Medico-Philoſophicis *Haffnienſibus* Anni 1673. Obſ. 122. f. 306.† eoſdem cum ſuccino habere affirmat natales, (poſtquam videlicet comprobaſſet *Succinum* arborum eſſe reſinam) nec dubium eſſe arbores odoratas in novo orbe ſimiles profundere ſuccos. *Tacitus* ut orientis arbores *Thura*, & *Balſama* (cur non & *Ambarum?*) ita & occidentis credibile ſudare ſuccinum ſcribit. Ex his omnibus opinionibus & conjecturis, quis opinioni, *Ambari* originem ab arboribus deducentium, utpote

A Treatiſe on Amber, *by* G. J. Camelli n. 290. p. 1591.

* *Joes Leon.* in *Deſcr. Africæ*, Piſcem *Ambara* Ambarum *ejicere ſcribit.*

† Quod & *Odoardus Barboſa* annotat.

verisimili ac probabiliori non subscribit? More fungorum etenim generari valde dubium est. Algas, aut maris recrementitiam putrilaginem materiam esse posse *Ambari*, non facile crediderim. Herbas aut arbores resiniferas in ipso mari enasci necdum constat. Bituminis, aut terræ genus esse, non est verisimile. Factitium esse, falsum est. Avium stercus, Elephantis semen, Balænæ, aut alterius Piscis esse liquorem, hepar, sperma, aut excrementum, fabulosum videtur. A *Balænis* nihilominus, aut aliis Cetaceis, aliquando Ambarum, tanquam nutritioni prorsus ineptum evomi, (quod & *Odoardus Barbosa* annotat) in earumve œsophago, aut ventriculo nonnunquam ut indigestibile invenire lubens concesserim, siquidem hujuscemodi monstrua oblatas offas, nequaquam, ut pueri poma, deligere, aut prælibare solent, sed quicquid faucium eorum hiatui influxerit, ingurgitant. Resinosum itaque, salvo aliorum judicio, liquorem, quem *Indi* variarum provinciarum *Agacabac* l. *Hagacbac*. *Bintogo* l. *Bintoco*. *Apitono*. & *Malibabo*. *Cayancang*. & *Bolotic* alii vocant, quemve unum eundemve cum eâ siccâ, & induratâ resinâ, quæ mihi de montibus *Ilocos* & *Paynan* in magnis allata fuit fragmentis esse judico, *Ambari* legitimam materiam esse suspicor. Verum, tempestuosâ obortâ procellâ, & pluviarum continuatione universali factâ inundatione a mediterraneis latebris, ac spineta inaccessibilium montium jugis, torrentium impetuoso ac versabundo cursu præcipitanter in mare delatum, ibidemque à decumana fluctuum exagitatione & concussione, æstuante marina aqua, nonnihil emollitum ac elotum, beneficio particularum Salis marini, nec non Solis demum accedentibus ardentissimis radiis, ita immutatum, elaboratum ac præparatum, ut tandem placato turbine ad littus refluis propulsum fluctibus a resina recenter ex arbore collecta, aut etiam tractu temporis in montanis desiccata, distinctissimam, violento nempe hocce beneficio acquisitam, præ se ferat formam* ; eamve ; prouti scilicet plusve minusve temporis aqua marina maceratum, fluctuum concussione elotum, ac Solis excoctum, seu dealbatum fuerit ardore, magis aut minus candidum. Verum communiter non nisi postquam Pluviarum continuatione mediterranea inundentur, & terribilium ventorum furiâ exagitatum fuerit mare, horrenda fluctuum concussione abyssos ipsos, & sinuum ac concavitatum latebras everrendo sordes tanti ponderis in littus rejiciuntur. Hujus conjecturæ certum, & evidens præbent Argumentum Anno 1694 Januario *Manilam* allata *Ambari* frusta grandiora, solida, pura & heterogeneis carentia, in littore circa *Palagpag* collecta. (Nota, sub finem *Februarii* 1693. horribilem exortam turbinem) erant autem *partim* coloris capacioris *succini flavi*, seu facie gummi *Arabicæ:* Vitro cristallino vix non pellucidiori de *Ilocos* missæ resinæ magis in luteum vergentia : Resinæ verò de *Paynan* allatæ propemodum similia, sed minus odora, usta videlicet, igne ut hæc & altera facilè liquescentia, & lapideæ ferme duritiei, ità ut nec culter, nec dentes, signum imprimerent. *Partim* seu latere uno ex candido grisea,

* *Barbosa* acres Soli & Lunæ continuo expositum resinare tradit.

varie fiſſa, friabilia quidem, ſed omni hucuſque à me viſo *Ambaro* ſolidiora. Pro *Ambaro* autem omnium optimo genuino, & legitimo divendita fuerunt. Huic meæ opinioni non invitus objecerat adverſarius, non poſſe eſſe *Ambarum* hujuſcemodi arborum reſinam, eò quod fruſta maxima reperta fuerint, cui reſpondebam fieri poſſe, ut varii hujus reſinæ glumi obvios inter fluctuum recurſus, aut etiam torrentium decurſus, utpote homogenei, & tenaces ſocientur, ſibi cohæreant, agglutinentur, & in fruſta majora denique abeant, ac conglomerentur. Et quid ni magna poſſibile eſt reperiri hujuſcemodi reſinæ fruſta, cum hujates montes arbores reſiniferas incredibilis alant verticitatis, & ad *Pilis* & *Lauvan* caudices ſæpius centenarii colligantur reſinæ, & fragmenta de *Ilocos* ac *Paynan* allatæ reſinæ ſanè maximum fuiſſe glomum, unde deſumpta fuerant, teſtentur. *Fran. Combes* in *Hiſt.* Inſularum *Mindanai* f. 15. refert in littore *Iolò*. (*Batavis* Inſula *Margarifera*) fuiſſe repertum fruſtum *Ambari*, bovini corporis trunco majus, ſed reſinæ ordinariæ loco vix non fuiſſe conſumptum. *Idem* referre videtur *Fran. Colin.* in *Hiſtoria Philipinarum* f. 49. ſcribens circa *Inſulam Iolò* fruſtum *Ambari*, griſei, & optimi inventum fuiſſe ultra ducentas libras pendens. Et idem *Ignatius Alzina* in *Hiſt. Byſaiarum* recenſere puto, qui dicit in *Iolò* fruſtum fuiſſe collectum corpore humano craſſius, & duplo longius vilique ob copiam diſtractum fuiſſe pretio. *An.* 1632. ad promontorium *Sancti Spiritus* in Coſta de *Igbabao* ambari fragmentum 55 circiter librarum inventum fuit, cujus uncia 30 Imp. quia ſanè optimum fuit, divenditum eſt. *Indus* ſiquidem, cui ſors obtigerat, tres impleverat corbes, quorum duos ob cognitionis, & exinde eſtimationis defectum, domus ſuæ illuminandi gratia reſinæ loco inſumpſerat (his uſibus antiquitùs, plerumque *Byſaianis*, Ambarum à reſina non diſtinguendo deſerviebat) idem facturus cum corbe tertio, niſi hoſpes magis verſatus ex odoris fragrantia, fumi rectâ aſcendentis diſtinctivo, non reſinam vulgarem, ſed nobiliſſimam, ſeu *Ambarum* eſſe prodidiſſet. † In *Bangahun* vetula conchylia legens, fruſtum magnitudinis brachii invenit, pro reſinâ odoriferâ ordinariâ habuit, (nam variæ & multæ reſinæ odoriferæ ſpecies à mari in littus propelluntur, ut *Batete*, Ambarum redolens, quam *Ambarum* quod vocant nigrum eſſe cenſeo; eo quod curatum, non ſemel pro viliori divendatur *Ambaro*. *Dairiangao*, *Raporago*, *Benzoini* redolent, *Tangay*, *Samato*, Aliis *Samata*, liquidambram, aut balſamum ſpirantes) ſuffumigiis deſtinavit, & fermè in totum antequam quid rei eſſet edocta fuiſſet, conſumpſit. *Ambarum* non rarò valde tenax, & picis liquidæ modò molle inveniri multi affirmant, quod & *Fran. Combes* inſinuat, dum ſcribit, aliquando in littore liquorem mollem, & recentem colligi, qui aſſervatus, nec non beneficiatus optimum eſſe deprehenditur *Ambarum*. Communis autem & vulgaris eſt opinio, quod & *Hieronymus de Huerta* cum *Fran. Combes*

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† *Caſpar Bayam* circa 1680. inter *Aden* & *Mecam* in alto mari *Ambari* truncum prægrandem obvium habuit.

affirmat,

affirmat, *Ambarum* crudum aut recenter collectum, fragranti carere odore: *Joh.* nihilominus *Botero Benes* f. 90 *Ambarum* in *Ava* proſtans, & non adulteratum odoris eſſe ſummè fragrantis, ac acuti, ut naribus admodum illicò ſanguinem profluere faciat. *Alphonſus* de *Ovalle* in *Hiſt. Chilenſi* ſcribit, *Griſeum* eſſe odoris ſuavis, *nigrum* acutioris, differentiam verò hanc odoris, & coloris inde provenire, quod nigrum griſeo breviori tempore in mare, ac Soli expoſitum fuerit. * Dealbationem itaque *Ambari*, & duritiem, ac denſitatem ſali, ſaliniſque maris particulis, prouti *Succini* Soliditatem *Thomas Bartholinus* in Actis Medico Philoſophicis *Haf.* Anno 1671. *Obſ.* 57. f. 113. adſcribemus. *Ambræ griſeæ* valde candicantis, & ut vocant, finiſſimæ, aſſervo partem (variè atterebratam) quinis conchyliis, & particulâ ligni putridi inhærente. Certum argumentum bonitatis gradum à diuturnitate elotionis, & morâ in maritimis fuiſſe aſſecutam.

Of the Aſbeſtus, *and the way of making the* Incombuſtible Cloth, *by Seignior* J. Campini. n. 273. p. 911.

XXIV. 1.] I have four ſorts of the *Aſbeſtus* in my *Muſæum*. The firſt from *Corſica* or *Corfu*, long, of a woody Form, of half a palm length and more, of a whitiſh Colour, ſomething inclining to a reddiſh. The ſecond of a ſilveriſh Lead Colour, ſofter and ſhorter, about three Inches, this was from *Seſtri di Ponente* in *Liguria*. The third (which is the worſt of all) is like Scales or *Laminæ* one upon another (like an Onion) of a blackiſh Earth Colour, with ſome white, black, and dark red Veins, interſperſed, ſcarce two Parts of an Inch *Roman* long, therefore fitter for making of Paper, than ſpinning or weaving. The fourth ſort, given me by Seignior *Boccone*, found in the *Pyrenæans*, ſome whereof were a *Roman* Palm long; its Filaments, though longer, were yet thicker and rougher; I have heard of another ſort in *Volateranis Montibus*.

Some have ſuppoſed, that the Wieks of the ſepulchral Lamps of the Antients were made of this; but from Experiments I conclude it unfit for that Purpoſe, always finding the Wieks made of it to go out, and not contract or continue up the Oil for the Flame.

I have kept it for 3 Weeks in a Glaſs-houſe Fire, but found it unalter'd; but it would not preſerve a Stick wrapt in it from the Fire; whence I conclude, the *Amiantus* loſes nothing in the Fire, becauſe it does not burn nor flame; but in the handling it waſtes, though not much, as I found by an exact Ballance.

As to the Manner of *Spinning* it, I have tried thus; firſt, I laid the Stone in Water (if warm, the better) for ſome Time to ſoak; then it is opened and divided with the Hands, that the Earthy Parts may fall out of it, which are whitiſh like Chalk, and hold the thready Parts together; this makes the Water thick and milky; this is repeated ſix or ſeven Times with freſh Water, where it is again opened and ſqueezed,

* *Sennertus* de Bitumine, *Ambram* odoratam, Bitumen eſſe ex maris fontibus manans, & in ſummo mari, aeri expoſitum denſari & coagulari, ut ſuccinum, cenſet.

till

till all the heterogeneous Parts are waſhed out, and then the Flax-like Parts are collected, and laid in a Sieve to dry.

Of the four ſorts of *Amiantus*, I found that from *Corſica* beſt, being long and ſoft; and the *Cyprian* worſt; I am in doubt, whether mine was of the beſt ſort, ſince the *Cyprian* was commended by *Pancirollus* and others. The Way of ſpinning it, diſcovered to me, was thus: Lay the *Amiantus*, cleanſed as before, between two Cards, ſuch as they card Wool with, where let it be gently carded, and then clapt up in between the Cards, ſo that ſome of it may hang out at the Sides; then lay the Cards faſt upon a Table or Bench. (*Fig.* 41.) Take a ſmall Reele, (*Fig.* 42.) made with a little Hook at the End, (*Fig.* 43.) and a Part to turn it by, (*Fig.* 44.) ſo that it may eaſily be turned round; this Reele is to be wound over with fine Thread; then having a ſmall Veſſel of Oyl ready, (*Fig.* 45.) with which the Fore-finger and Thumb are conſtantly to be kept wet, both to preſerve the Skin from the corroſive Quality of the Stone, and to render the Filaments thereof more ſoft and plyant: thus by twiſting the Thread upon the Reele about, with the *Aſbeſtus* hanging out of the Cards, ſome of it will be worked up together with it; by little and little this Thread may with Care be woven into a coarſe ſort of Cloth, and by putting it into the Fire, the Thread and Oyl will be burnt away, and the incombuſtible Cloth remain. But finding this Way of uniting the Stone with the Thread very tedious, inſtead of the Thread I put ſome Flax upon a Diſtaff; and by taking three or four Filaments of the *Aſbeſtus*, and mixing them with the Flax, I found they might eaſily be twiſted together, and the Thread thus made much more durable and ſtrong: So that there is no Need of carding, which rather breaks the Filaments, than does any Good; open only and ſeparate the Filaments after waſhing upon a Table, and take them up with the Flax, which is ſufficient. As to the making of Paper, in the waſhing the Stone, there will remain ſeveral ſhort Pieces in the Bottom of the Water, and of theſe after the common Method Paper may be made. Fig. 39, 40. Fig. 41. Fig. 42, 43, 44. Fig. 45.

The beſt Way of preſerving the Cloth, or any other Thing made of the Stone, when made (for by Reaſon of its exceeding Dryneſs it is very apt to break and waſte) is to keep it always well oyled, which is the only Preſervative for it; and when the Cloth is put in the Fire, the Oyl burns off, and the Cloth comes out white and purified.

2.] In the Grounds of *Francis Gordon* of *Achindore*, in the Shire of *Aberdeen*, near the *Highlands*, on the Side of a Hill of a Heath kind of Ground, ſomewhat inclining to what we call Moſs, in a very ſmall Brook, and hard by it, in the Bounds of ten or twelve Yards, I found a great many Stones, ſome a Foot in length, which appeared plainly like Wood: But becauſe I could not perceive any Footſtep of Wood thereabout, neither could any of them be found, except in that very Spot of Ground, I could not be perſuaded they were petrified Wood. Then

— Aſbeſtus, *&c. found in* Scotland, *by Mr.* Wilſon. n. 276. p. 1000.

I went to cut up the Ground about the Place with my Knife, where I found likewiſe ſome Pieces of the Stone, and very near the Superficies I got ſeveral Pieces of a fibrous Matter, which my Knife could not cut; this I immediately judged to be an *incombuſtible* Matter, as it proved afterwards, when I try'd it by the Fire. And becauſe, ſo far as I then remember'd I had heard or read of it, I thought it had been always eſteemed certain Filaments that came off the *Lapis Amianthos*, I reſolved to obſerve more narrowly the Production of it.

When I found ſome Pieces of the Stones very hard in the Middle, and the fibrous Matter on the Outſides and Ends, I was inclined to believe that the Flax came from the Stone: But then finding ſeveral Pieces of the Flax ſo condenſed and preſſed together, that at firſt they appeared to be hard Stones, but being a little wet, the Filaments were eaſily parted from one another. Many more I got, ſome leſs and ſome more condenſed into the Nature of a Stone; and all of it, both that which was condenſed together, and what was not, was lying about an Inch within the Ground, parallel with the Surface ſo interwoven with the Fibres of the Roots of the Graſs, that it ſeemed to me much more probable to believe, that the Lint turned into the Stone, than the Stone into the Lint: Eſpecially ſeeing moſt Part of the Stones appeared ſo tender and brittle on the Outſide, that it's hard to believe how they could turn into that tough Subſtance of Flax.

The Stones are of different Sorts, ſome are white, the Colour of the Lint, and of a very ſoft Subſtance; ſo they may be eaſily cut with a Knife without blunting it; others are much mix'd with a whitiſh *Talk*, but moſt of them are of a greyiſh Colour, and very hard.

As for the Production of the Flax, I think it's hard to determine in this Place; becauſe the greateſt Quantity I found of it was lying, as I ſaid before, about an Inch at moſt within the Ground, parallel with the Superficies, interwoven with the Roots of the Graſs, without any Root of itſelf, but alike at both Ends, as if it were cut with a Knife. The Ground wherein it is found is of a greyiſh Colour, about one Inch or two thick, under which there is a black Earth for a Foot in Depth. So that I could find nothing in the Places where moſt of it was got, that I could rationally conclude to produce it: But in ſome other Spots I found much of a *Talkiſh* Sand, and ſome Pieces of Flax near to it; as alſo Pieces of the Stone much whiter than the reſt, and very like *Talk*; which would incline one to believe that it was produced of it. Yet there being no Appearance of any *Talk* in the other Places, where moſt of it was found, I can ſcarce conclude any Thing about the Production of it, but leave it to others.

Pliny, *Aldrovandus*, and *Olaus Wormius* make it very ſhort, whereas ſome of this I found five, ſix, ſeven, and ſome eight Inches long.

As for the making of it into Cloth, they all conclude it very hard: *Pliny* calls it *inventu rarum*, *textu difficile propter brevitatem*. *Olaus Wormius*

Plate IV. Vol. IV. Part II. Page 284.

Fig. 37.

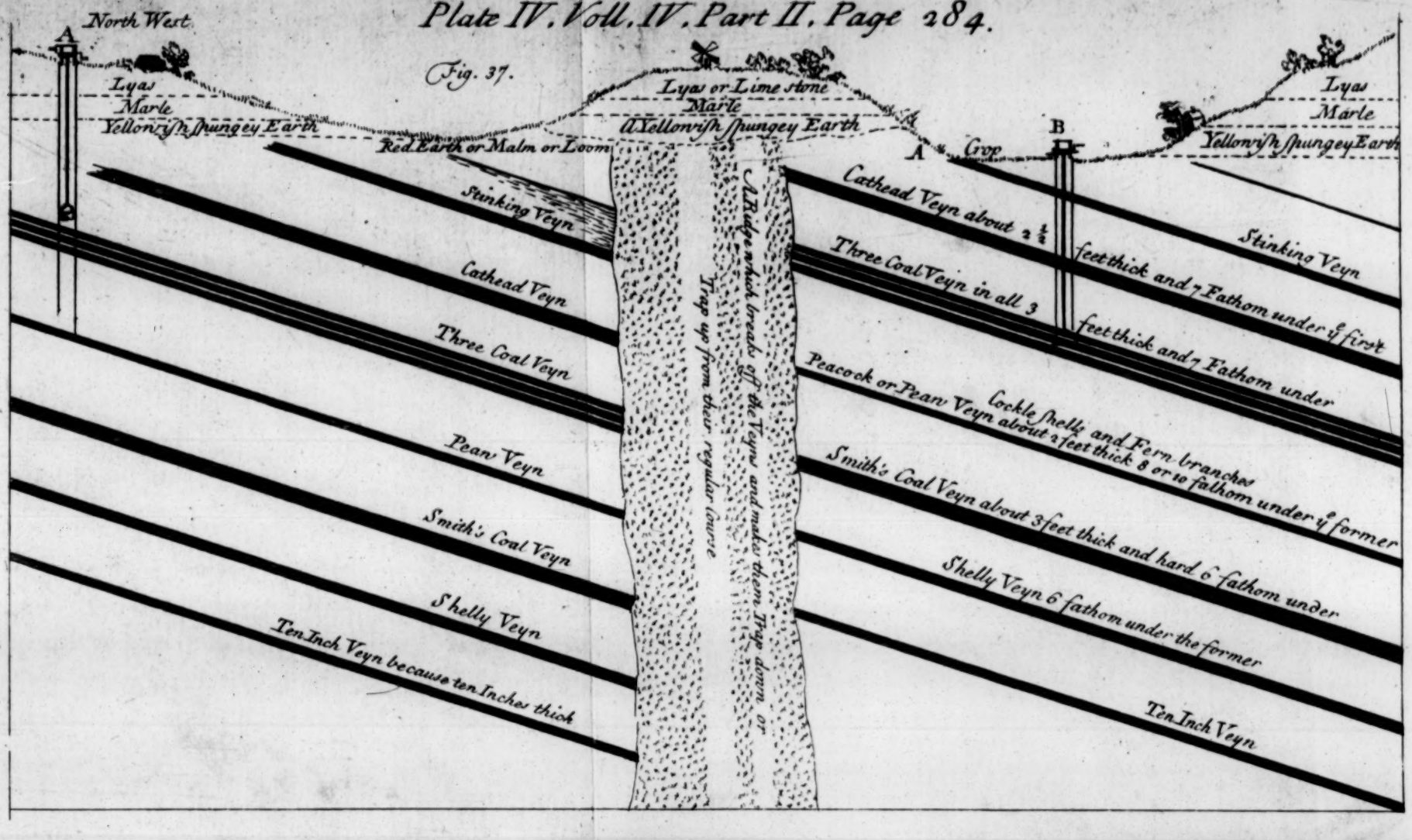


Fig. 39.

Fig. 45.

Fig. 40.

Fig. 43.

Fig. 42.

Fig. 41.

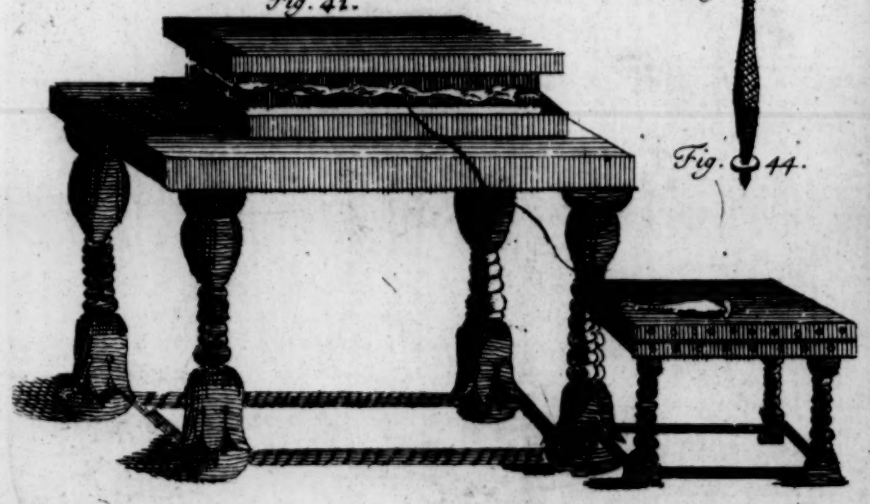
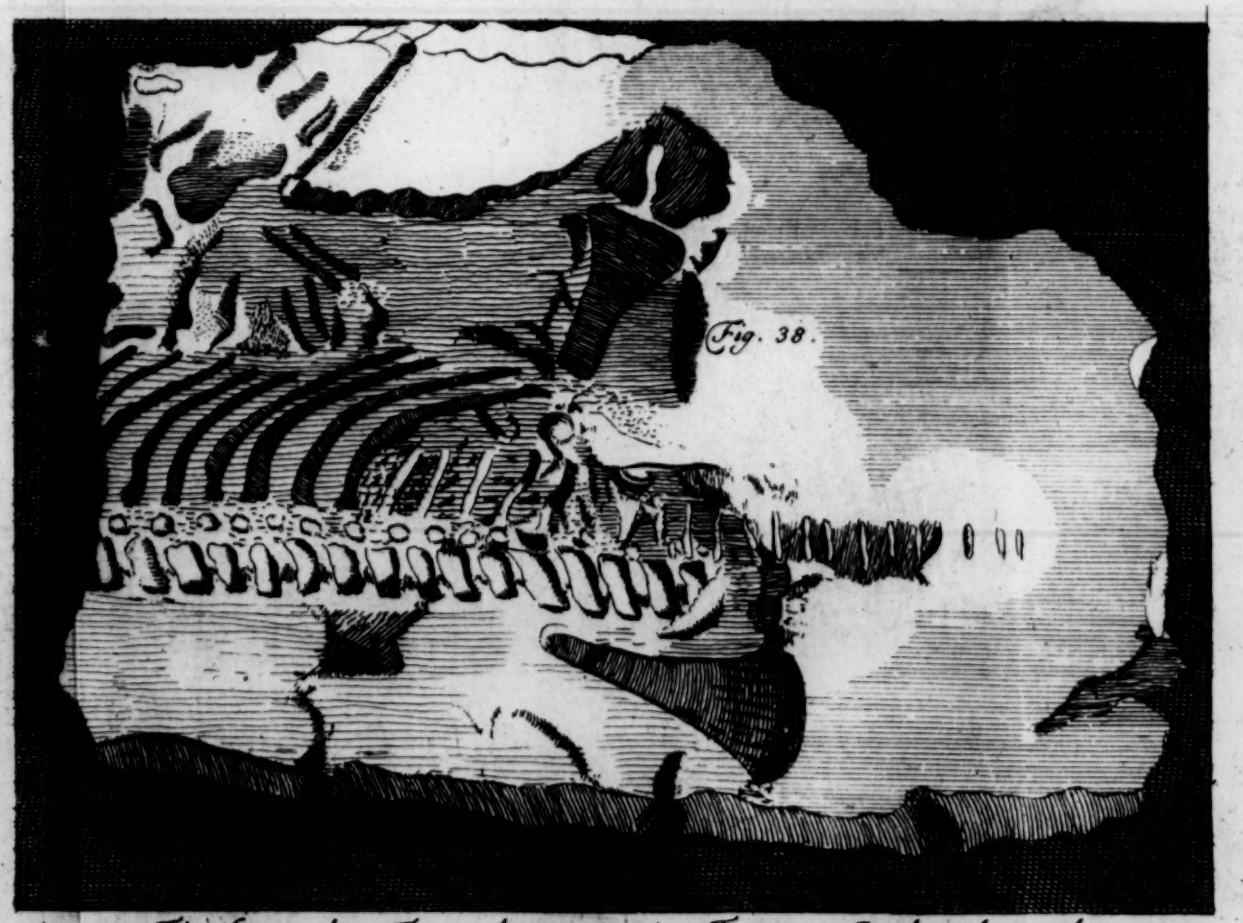


Fig. 44.

Fig. 38.



The Stone is 3 Foot long, and 2 Foot 2 Inches broad.

mius in his *Muſæum* ſays, *Modus vero, quo ex eo fiunt lina, jam penitus ignoratur.* I confeſs indeed, it is true what *Pliny* ſays; yet it may be ſeen, by the Experiment I have ſhewn, in making Yarn of it, that Cloth may be made of it alſo, for the Difficulty is much greater in the one than the other.

3.] I receiv'd the following Account from a Gentleman in the *Highlands*, (not many Miles from *Coupar* of *Angus*) who had lately built an Houſe of a *ſingular* kind of *Stone*; digg'd out of a Quarry not far from him. This Stone, after the Rubbiſh (which is not very deep) is done away, lies Horizontally in a Bed endu'd with parallel Fibres, with few Interſtices, ſoft at the Beginning, and eaſy to be ſmooth'd and poliſh'd without any Tool, but rather with Sand, or an other hard Stone of a blueiſh Colour, which afterwards hardens ſo, that it reſiſteth the Injuries of Air or Prejudice of Fire. When firſt the Quarrier began to dig it, he was at a mighty Loſs; for endeavouring to cut and raiſe it after the ordinary Manner with Wedges, and other uſual Inſtruments, it broke and crumbled all to Pieces: But afterwards, obſerving more narrowly the Duct of its Fibres (ſo to ſpeak) he endeavoured to cut it with Spades lengthways; and by this Means he procured Stones as big as he had a Mind, which ſmoothed very eaſily along the Tract of their Fibres; but when cut tranſverſe, no Means nor Methods could render them ſmooth, but their Surface remain'd unequal as the Extremities of a Piece of Wood. Although this Quarry has but few Interſtices, yet in thoſe it has the true *Aſbeſtos*, of a whitiſh Silver Surface, conſiſting of ſeveral *faſciculi* with parallel Fibres, like to thoſe of the muſcular Fibres of ſalted Beef; eaſily ſeparable from each other, pure white, till it becomes ſo ſmall as the fineſt Flax; and ſo ductile, that it may be ſpun into the fineſt Thread, whereof it were eaſy to make the incombuſtible Cloth, ſo famous for Shrines among the Ancients. In other Places of thoſe Interſtices was likewiſe to be obſerved a reddiſh Subſtance, near to the Colour of *Sanguis Draconis*; but whether Fibrous or not, I cannot ſay, ſince the Gentleman could not ſhew me any of it; but added, he believed it might be good for dying. I got a ſmall Parcel of the *Aſbeſtos* from him; and he told me, if he had known its Value, he could have preſerv'd ſome Pounds of it. I am ready to think the ſecond kind was Fibrous too, which might make a very beautiful Cloth, being ſtriped with the other. This whole Quarry may be ſaid to be *Aſbeſtos* of different Colours, the blueiſh being of a much coarſer, and the white and red of a finer Grain.

— *on the* ſame, *by Mr.* P. Blair. n. 333. p. 434.

XXVI. *Papers Omitted.*

1. A Deſcription of ſome *Shells*, brought from the *Molucca Iſlands*, by Mr. *Sylvanus Landon*, and Mr. *Rowleſton Jacobs*, by Mr. *J. Petiver*. n. 274. p. 927.

2. A Deſcription of ſome *Shells*, ſent from *Fort St. George*, by the Reverend Dr. *George Lewis* to Mr. *J. Petiver*, by the *ſame*. n. 2 2. p. 1266.

n. 299. p. 1952. 3. An Account of ſome *Shells* and *Animals* ſent from *Carolina* to Mr. *J. Petiver.*

n. 286. p. 1419. 4. A Deſcription of ſome *Corals*, and other curious *Submarines*, ſent from the *Philippine Iſles*, by the Reverend *G. J. Camelli* to Mr. *J. Petiver.*

n. 301. p. 2042. 5. Catalogus *Concharum foſſilium*, *Metallorum*, *Mineralium*, &c. quæ a Cl. D. *Johanne Scheuchzero* nuper accepit D. *J. Petiver.*

n. 302. p. 2082. 6. *Mineralia* quædam, *Conchylia* petrefacta, & alia *Foſſilia* è *Berolino*, a Cl. *Chriſtian. Maximiliano Spenero*, Doct. Med. Reg. *Pruſſ.* Aul. Acad. S. R. I. Cur. & Soc. Scient. Reg. *Brandenburg.* Colleg. ad D. *J. Petiver* miſſa.

n. 311. p. 2397. 7. De *Conchyliis Turbinatis*, *Bivalvibus* & *Univalvibus*; item de *Mineralibus*, *Foſſilibus* & *Thermis Philippenſibus*, ex MSS. R. P. *Geo. Joſ. Camelli* communicavit D. *J. Petiver.*

n. 337. p. 222. 8. A ſhort Account of ſome *Swediſh Minerals*, &c. ſent from Mr. *Angeſtein*, Overſeer of the King of *Sweden*'s Mines, to Mr. *J. Petiver.*

n. 314. p. 77. 9. An *Advertiſement* of a *Catalogue* of ſeveral Specimens of *Figured Foſſils*, to be had of Mr. *Alban Thomas.*

XXVII. *An Account of a Book omitted.*

n. 291. p. 1604. Specimen *Lithographiæ Helveticæ* curioſæ, quo Lapides ex Figuratis *Helveticis* Selectiſſimi Ære inciſi ſiſtuntur & deſcribuntur, a *Johanne Jacobo Scheuchzero*, M. D. *Tiguri* 1702. 8*vo.*

CHAP. IV.

Magnetics.

Of the Invention *and* Improvements *of the* Mariner's Compaſs, *by Dr.* J. Wallis. n. 276. p. 1035. n. 278. p. 1106.

I. THE Doctrine of the *Magnet* has been, I believe, more improv'd by the *Engliſh*, than by any other Nation; and I am of Opinion, that the *Mariner's Compaſs* was originally an *Engliſh* Invention; not only becauſe *England* was of old as famous for Navigation as any other Nation, long before the *Holland* Sea-Trade was in being; but (ſince new Inventions commonly take their Names from the Place where the Invention itſelf is taken) from the *Name* itſelf of the Mariners *Compaſs.*

The Word *Compaſs* (in Latin *Circulus Nauticus*) is an antient *Engliſh* Word, for what we otherwiſe now call by a *French* Name a *Circle.* In *Kent*, where I was born and bred, it was commonly uſed in that Senſe, when I was a Youth; and *Minſhew* in his Dictionary takes *Circle* and *Compaſs* indifferently to ſignify the ſame with *Circulus:* And hence it is that *Circinus* is in *Engliſh* call'd a *Compaſs*, (or a *Pair of Compaſſes*) as being the Inſtrument wherewith we deſcribe a *Compaſs* or *Circle*; but whether

whether *Circinus*, call'd by us a Pair of *Compaſſes*, may have ſome like Name in another Language, I do not know, nor how antiently.

I do not know that the Word *Compaſs*, or any Word like it, was ever uſed in any other Language for a Circle *Indefinitely*, or for any *other* Circle than the *Circulus Nauticus*. In *French* it is *Cercle*, *Cerchio* in *Italian*, *Circulo* in *Spaniſh*, or ſome other Word deriv'd from the *Latin Circulus*; and from hence the *Circulus Nauticus* may come to be call'd the *Mariners Compaſs*, which Name being given it by the firſt Inventors, might give Occaſion for like Names in other Languages, *French*, *Italian*, *German*, &c. *Compaſs*, *Compaſſo*, *Zee-Compaſs*, &c. which Name, together with the Art, I gueſs they borrow'd from *England*.

I might urge the ſame from another Name, *Boſſolo*, *Boſſola*, &c. For as *Circulus Nauticus* is the *Mariners Compaſs*, ſo *Pyxis Nautica* is the *Mariners Box*, (for the *Engliſh Box* is from the *Latin Pyxis*) and *Pyxidula* (as a Diminutive from *Pyxis*) muſt be *Boxel*, or ſome Word like it, which eaſily paſſeth into the *French Buxole*, *Bouſſole*; and the *Italian Boſſola*, *Bouſſula*; which all ſeem to be from the *Engliſh Boxel* (*Pyxidula*) *a little Box*; ſoftening the ſound of the Letter *x* in *ſſ*; as in *Aleſſandro* for *Alexandro*.

All which, though it be not a direct *Demonſtration*, yet (ſince it is not agreed by whom, or where the *Compaſs* was invented) may in the Silence of Hiſtory be admitted as a probable *Conjecture*, and a plauſible *Pretence* to the Invention, till a better claim do appear; for *New Inventions* commonly take their *Names* from whence the Invention itſelf is taken.

And where Inventions creep in by Degrees, it muſt not be thought ſtrange, if it be not eaſy to ſay, who is the *Firſt Inventor*.

In the preſent Caſe, he who firſt obſerved (I know not by what Accident) that the *Magnet* hath a *Polarity*, or Inclination Northward, made the *Firſt Step* towards this Invention. This (I think) was at firſt wont to be ſhewed, by putting a Magnet into a little Boat, ſwimming on Water, when it was obſerved, that this Magnet would of itſelf ſo ſteer this little Boat, as that a certain Point in the Magnet would (if not hindered) turn toward the North. Which Point was thereupon called the Magnet's *North Pole*.

He that afterward obſerved that this Verticity, or Polarity, was communicable to a Piece of Iron or Steel, rubbed on a Magnet, added a further Step.

And he who contrived a Way to ſet a Needle or Piece of Steel ſo touched on a ſharp Pin, ſo as in the Air to move horizontally thereon, ſo as of it ſelf to find out the North, and point toward it, as before the ſwimming Magnet in its Boat had done on the Water, had now diſcovered a new Experiment in Natural Philoſophy, very ſurprizing.

But this cannot yet be called *Circulus Nauticus* (or the *Mariners Compaſs*) till they had further contrived a Way how to put a Needle

thus poiſed into a Box, with a Compaſs or Circle round it; ſo divided as to denote the *Azimuthal* Points of the *Horizon*, or, as they be now called, the *Points of the Compaſs*; and ſo commodiouſly to fix this Box, ſo prepared, to the Ship, as thereby to inſtruct the Mariner or Steerſman toward what Point of the Compaſs the Ship moved; that by the Help of the Rudder he might put it into ſuch a Courſe, as was proper for his Voyage. And it was now indeed *Pyxis Nautica* or *Circulus Nauticus*, (the *Mariners Box* or *Compaſs*) but not till then. And he who firſt contrived this Application, did *compleat* this Invention of *Circulus Nauticus*. But all thoſe antecedent Diſcoveries were Steps towards it, and Parts of the Invention.

Now it is not likely that all theſe Diſcoveries were made at once, by the ſame Man, at the ſame Time, but ſucceſſively, by the joint Advice of divers inquiſitive Men, and in a conſiderable Tract of Time; yet all perhaps of the ſame Nation, and probably the *Engliſh*.

But whoever gave the firſt Hint of this Invention, certain it is, that the great *Improvements* of the Magnetick Doctrine are due to the *Engliſh*, and chiefly to thoſe about *London* and *Greſham* College. And it is fit the Memory of it ſhould be preſerved.

The Caſe is much the ſame with that of *Printing*, which we cannot reaſonably ſuppoſe to be invented all at once, nor perhaps all by the ſame Man; but rather, by the concurrent Advice of divers, and in a conſiderable Tract of Time, before it came to that Degree of Perfection which we now call *Printing*.

It might be firſt obſerved, that the Shape of a Letter, Figure, or Picture, graven on Wood or Metal, might (with help of a convenient Preparation of Oil, Ink, or coloured Liquor) be ſtamped on Paper; and, if once, then as oft as you pleaſe.

And if by ſtamping the Print on Paper, then as well by due Application of the Paper to the Print, thus prepared.

And if one, then by the ſame Reaſon to two or more, if fitly conjoined, and even to a whole Page at once; and, of that, as many Copies as we pleaſe.

But, this being admitted, it remains further to be contrived, how all theſe Prints or Stamps for a whole Page ſhall be ſo compoſed into one Frame, that the Paper may be applied to all at once.

It is then to be conſidered farther, what kind of *Ink*, (or ſomewhat inſtead of Ink) is to be applied to the Face of the Letters, thus compoſed; for common Writing-Ink will not ſerve the Turn.

Then, how the Paper ſhall be applied (with an equal Preſſure, and ſufficient) ſo as to take off juſt ſo much of that Ink, as repreſents the Face of thoſe Letters, and no more.

And after all this, it muſt be further contrived, how to erect ſuch a Structure, as what we now call a *Printing-Preſs*, and how to manage it, ſo as to anſwer all theſe Exigences: For, till all this be done, we

are

are not arrived at what we call *Printing*. But all thoſe previous Contrivances, muſt be owned as *Parts* of the *Invention*.

And in the *Magnetick Doctrine* likewiſe. And to thoſe *previous* Diſcoveries, muſt be added, the *Subſequent* Improvements of Magnetick Knowledge, ſince the firſt *Uſe* of the *Mariners Compaſs*.

But whoever was the firſt Inventor of the *Mariner's Compaſs*, it is certain, that the *Doctrine* of the *Magnet* has receiv'd very great Improvements from the *Engliſh*; from *Blagrave*, *Gunter*, *Gellibrand*, *Gilbert*, *Norwood*, *Wright*, *Brigs*, *Foſter*, &c. and of late by Capt. *Halley* in his *Map* of the *Magnetick Variations*; which I look upon as an excellent Deſign, well contriv'd, and well executed, and which fixes the Buſineſs of the Magnetick Variation in theſe Seas for the *preſent* Time.

I think it is agreed on by all Hands, that what we call *the Variation of the Needle*, is an *Engliſh Diſcovery*, (of Mr. *Gellibrand*, if I miſtake not, one of Sir *Thomas Greſham*'s Profeſſors at *Greſham* College) about the Year 1625. that is, that the *Magnetick Needle* in its horizontal Poſition doth not retain the ſame *Declination* or *Variation* from the true North, in the ſame Place, at all Times, but doth ſucceſſively *vary* that Declination from Time to Time; which, though it were about that Time a *New Diſcovery*, is now admitted as an undoubted Truth.

It was about the Beginning of the Reign of King *Charles* the Firſt, that Mr. *Gellibrand* (if I have not been miſinformed) cauſed the Great *Concave Dial* to be erected in the *Privy-Garden* at *White-Hall*, with great Care to fix a true *Meridian-Line*; and with a large *Magnetick Needle*, ſhewing its *Variation* from that *Meridian* from Time to Time. And I think it were not amiſs, if exact Obſervation were now made, whether the *Meridian* be now juſt the ſame as it was then; for it is very poſſible, that the *Pole* of the Earth may in Time ſuffer ſome little Variation (which may not readily be diſcerned) which may cauſe an Alteration of the *Meridian* Line: And this, if ſo, will be more diſcernible nearer the Pole, than farther off.

What we call the *Dipping Needle*, is admitted alſo to be an *Engliſh* Diſcovery, (I think of Mr. *Blagrave*'s) ſomewhat older than the former, that is, that the *Magnetick Needle*, beſides its *Horizontal* Direction toward the North, hath alſo a Direction of *Altitude* above the Horizon, if ballanced on an Horizontal Axis; pointing, as it were, with its Northern End in our Climate to ſome Point within the Body of the Earth. Whether or no this Direction do vary from Time to Time as doth that of its Horizontal Poſition Northward, I cannot tell; nor do I know whether or no it hath been yet obſerved; nor whether or no the Southern End in other Parts of the World do *dip*, as the Northern End doth with us.

'Tis alſo an *Engliſh Obſervation*, that not only a *Magnetick Needle*, but any Piece of *Iron* (if kept long in the ſame Poſture) ſhall of it ſelf contract a *Polarity*. As for Inſtance, an erect Bar in a Window, after long continuance in that Poſition, will, if duly poiſe'd, be found with its upper

upper End, to point toward the North; and Southward with the other End. And if afterwards it be continued long in a contrary Poſition, it will attain a contrary Polarity.

And Mr. *Gilbert*'s Notion (of the Earth's whole Body being but one great Magnet; and, leſſer Magnets being ſo many *Terrella*'s, ſympathizing with the whole) is *Engliſh* alſo.

It hath been obſerved alſo, that a magnetick Needle, if heated red-hot, will loſe its Polarity; and, if then cooled in a contrary Poſition, will acquire a contrary Polarity.

It hath alſo been obſerved by our *Engliſh* Mariners, (and, I think, more than once) that, upon a great Flaſh of *Lightning* at Sea their Magnetick Needle hath loſt its former Polarity, and contracted the contrary.

In general, the Doctrine of *Magnetiſm* hath been more improved by our *Engliſh* Naturaliſts, than (for ought I know) by any other Nation. And, if ſome one would take the Pains to give us a true Hiſtory of theſe (and the like) Improvements, it would be an acceptable Work, and for the Honour of the Nation.

Magnetical *Experiments and Obſervations, by Mr.* W. Derham. n. 303. p. 2136.

II. 1.] Having lately invented an *Azimuth Compaſs*, as I was preparing it for obſerving the *Magnetick Variation*, I took Occaſion to try divers Magnetick Experiments, and by that Means happened upon this odd *Phænomenon*.

Having touched a Piece of Wire, ſo that it ſtrongly tended N, and S, I was minded to ſee whether it would have any Inclination to either of the Poles of the World, when turned round like a Ring, ſo that the two Ends of the Wire met: And having again ſtraitened it, I was ſurprized to find it had quite loſt its *Verticity*; the Cauſe of which, I preſently concluded, to be the Contact of the Northern and Southern Ends of the Wire, which I thought might ſo influence one the other, as to confuſe its Poles; although I confeſs I had never obſerved any ſuch Confuſion to ariſe upon the bare Contact of the Northern and Southern Ends of two other touched Pieces of Wire.

Upon this, I touched ſtrongly the ſame, and other Pieces of freſh Iron Wire, and having found them all greedily to turn N, and S, I coiled them round ſo as that the Ends ſhould not come near one another, and again ſpeedily opened them ſtrait; and found, as before, that every Piece had utterly loſt its *Verticity:* Nay, the *Magnetick Virtue* was ſo abſolutely deſtroyed by bending the Wire, that it had not only loſt its Inclination to either Pole, but the two Ends of each Wire ſeemed indifferent to the Poles of the *Loadſtone*, *viz.* whereas before the bending, the adverſe Poles of the *Loadſtone* would repel, and the ſimilar Poles attract the adverſe, or ſimilar Ends of the Wire; now the repulſive Virtue was quite extinguiſhed, and either End would indifferently be attracted by either Pole of the Magnet; all one as if the

the Wire had been heated red-hot (which is well known to deſtroy the Virtue) or never had been touched at all.

This I experimented over and over again upon Wires of different Lengths, with the ſame Succeſs. Only this muſt be obſerved, if you only bend the Wire round, ſo as that it ſhall ſpring back into its Place, or recoil, ſo as to be near the ſame Straitneſs, that then no ſuch, or but little of ſuch, Effect will enſue. But to produce this Effect, the Wire muſt be *ſharply* bent, ſo as that *Violence* may be exerted upon it. If it be coiled two or three Times round a ſmall round Stick, it will beſt ſucceed. And farther alſo, it is neceſſary that every Part of the Wire ſhould be bent, to evacuate the Magnetic Virtue: For if the Ends, or any other Part happen not to ſuffer the Violence of bending, that Part ſhall retain its Magnetiſm; As for Inſtance, if the Wire be all coyled, except half an Inch, or indeed half a tenth of an Inch at each End, every Part ſo coyled ſhall both loſe its Verticity, and ſhall incline indifferently to either Pole of the Magnet; but the two Ends (although not able to turn the whole Wire N. and S.) ſhall fly from, or tend unto the reſpective Pole of the Magnet: Or if every Part of the Wire be coyled, except a ſmall Bit at one End only, all that coyled Part, when extended, ſhall utterly be deprived of its Magnetiſm as before; and only that uncoyled Bit retain its Averſion, or Inclination to the Magnetic Poles.

From the Conſideration of all which Particulars, it is very manifeſt, that the Violence exerted upon the Wire by bending, doth utterly extirpate the Magnetic Virtue, or at leaſt make ſuch a Confuſion therein, that it is as if wholly deſtroyed: Which is a Caſe very odd, and never (that I have ever met with) taken Notice of before.

2.] The Account which I lately gave of the *Deſtruction of the Magnetic Virtue* in a touched Piece of Iron-Wire, by *Bending*, or *Coyling round*, I thought had been New: But by looking over what others have written of Magnetics, I find in *Grimaldi de Lumine & Colore*, that he, and in our *Phil. Tranſ.* N. 188. * that M. *de la Hire* had hit upon the ſame Diſcovery before me. And I am glad that I have the Authority of others on my Side, the Experiment not ſucceeding in ſome Tryals ſince.

Further *Obſervations on the* ſame, *by the* ſame. *ibid.* p. 2138.

* *Vid.* Supra. V. II. C. IV. S. IX.

The Matter of Fact was thus, and to me ſurprizing: I touched and coyled ſeveral Iron-Wires, but the Effect that enſued was not ſuch as I told the Society. The Verticity was indeed much weakened, but not totally deſtroyed, and the Ends of the Wires would be attracted or repelled by the Poles of the Magnet; whereas I ſaid they uſed only to be attracted. The next Morning I tryed again; and then the Magnetiſm of the Wires was totally deſtroyed, as I related. This Experiment I repeated divers Times, and on divers Wires this Winter, and commonly find, that, all the Day, coyling will evacuate the Magnetiſm; but that it will not abſolutely do it in the Evenings. But whether it will

will do ſo in Summer, or all Weathers, or whether it ſucceedeth thus only in different Times of the Day, I muſt leave to farther Tryals. I well know that the Orb of the Activity of Magnets, is larger, or leſs, at different Times. That noble Magnet in the Society's Repoſitory, found in *Devonſhire* by Dr. *Cotton*, is known in ſome Weathers (or at ſome Times) to keep a Key, or other Piece of Iron, ſuſpended to another Iron at 8, 9, or 10 Feet Diſtance. But at other Times, the Iron will drop down at the Diſtance of 3 or 4 Feet from the Magnet. Now whether at all, or how far this may reach the fore-mentioned Caſe, I cannot ſay, not having as yet ſufficiently experimented the Matter.

Finding the Caſe thus with *Coyled*, or *Bent Wire*, I was minded to try the Event of *Twiſting* of Iron-Wire from End to End, after it had been well touched. The Succeſs was, the *Verticity* was always weakened, and ſometimes inverted. And when it was ſo, the Load-ſtone did accordingly commonly repel or attract, all one as if the twiſting the Wire had given a new Touch the contrary Way.

But in ſome Wires ſo twiſted, the Verticity was wholly deſtroyed, or rather much confuſed: For I found by drawing one of the Poles of the Load-ſtone along near the Sides of the Wire, that in ſome Places it would attract, in others repel, and ſo attract and repel all along the Wire. Nay, I fancied in ſome Places, that one Side of the Wire would be attracted, the other repelled by one and the ſame Pole of the Load-ſtone.

To theſe odd Changes I could add divers others, which the *Twiſting* produced: But theſe do ſufficiently ſhew, that the Magnetic Virtue is put into great Confuſion by the Violence exerted upon the Wire by *Twiſting:* Which not only ſeparateth the Fibres of the Iron (as may be ſeen with the Eye, eſpecially aſſiſted with a Microſcope) but alſo changeth their Situation from Longways to Screw-ways.

I then try'd what would be the Iſſue of *Splitting* or *Cleaving* touched Wires: Particularly whether they would exert the ſame Effects that Magnets are ſaid to do, when ſawn in two Meridionally. Concerning which Dr. *Ridley* * ſaith, "Cut a Piece from a Magnet-ſtone meridionally, and that End which was placed S. when it was whole, being "ſevered, will turn North, although naturally at firſt it was the S. "Point." But Mr. *Barlow* is of a contrary Mind, and ſaith, That the Poles of ſuch a Piece of Magnet, when ſevered, will abhor the ſame Poles, to which it grew in the whole Magnet. But he ſubjoyns †; "But here you muſt beware of an Error, which ſome "unhappily have entangled themſelves withal, who beholding the "afore-mentioned Diſcord, wrongfully ſuppoſed, that if both theſe "Magnets the greater and the leſs [*i. e.* the Piece cut off] were "conveniently placed to ſwim in Water, the little one would not "with his End point unto the South of the Earth as it did in the Mag-"net being entire, when it was a Part of the true North End, but "would point contrarily. There is (ſaith he) no Manner of any ſuch "Alte-

* *Treatiſe of* Magnet. Bodies *and* Motions. Ch. 9.

† *Magnet. Advertiſements.* Ch. 2.

" Alteration, but that both the great one, the little one, and all the " like, that are cut Meridionally one from another will abſolutely " point the ſame Way which the entire one did. Only the Meridian " will be ſomewhat removed, *&c.*

Dr. *Gilbert* is as expreſs as Mr. *Barlow*. For (*L.* 2. *c.* 5.) ſpeaking of a Magnet divided, and ſhewing how that the Parts, which in the whole Stone coaleſced, do by Separation repel one another, he ſaith, *That what was the N. and S. Pole before, is ſuch ſtill. Non enim* (ſaith he) *immutatur Verticitas (quod malè affirmat* B. Porta.) *Nam licet* [*Poli ſeparati*] *non conveniunt, ut alter ad alterum inclinaret; tamen uterque in idem Horizontis punctum convertuntur.*

How the Truth lieth between Dr. *Ridley* and the two latter Authors, I cannot determine, having never ſo cut a Magnet. But by the Magnetic Laws, as well as from the Authority of Dr. *Gilbert* and Mr. *Barlow*, I doubt not but the latter is the trueſt Opinion.

But in *Cleft Wires* the Caſe is very uncouth: Oftentimes the Poles are quite changed: So that what was the *North*, becometh the *South* Pole of the Wire in all Reſpects; I mean, not only turning, but alſo embracing, or avoiding the Poles of the Load-ſtone, as if it had received a new, and contrary Touch. Sometimes one half of the Wire will retain its Magnetiſm, which it had before ſplitting, and the other half have it quite changed. Sometimes no Change at all will enſue, only the Magnetiſm be much weakened; as indeed it always is in all the Experiments where the Wire is ſplit. (But generally, where one of the Halves hath ſuffered Change, the other not, I have obſerved, That 'tis the thinneſt and weakeſt that hath been changed, and the thickeſt hath retained its Touch.) Sometimes where one of the Split Halves received an *inverted Verticity*, or ſeemeth to have no Verticity at all, one of its Ends will incline to one of the Poles of the Magnet, not according to its Touch, but in an inverted Order, and the other End be attracted indifferently by both the Poles of the Loadſtone. And in ſome Caſes, that End ſhall be attracted by one Pole, but be neither attracted nor repelled by the other; but ſtand as it were heſitating whether it had beſt fly to, or from that Pole of the Loadſtone. Only if that Pole of the Magnet be too near, then that End of the Wire will conſtantly fly thereto: As indeed it is the Nature of all Magnets and Magnetic Bodies to do, when they touch or approach very near one another, though they repelled before.

The Cauſe of theſe great Changes in touched Wire produced by *Splitting*, I have ſometimes imagined to ariſe from the Violence exerted thereon by bending. But in ſome Wires that I ſplit, or cleft with very little bending, one half hath been utterly changed, the other not.

In others that I cleft, by ſuffering the Halves to bend as much as they would, no Change hath been; and ſome have quite ſuffered Change.

Sometimes I have imagined that the Splitting the Wires in a N. or S. Poſition, or that the Beginning to ſplit at the N. or S. End of the Wire firſt, might be the Cauſe of this Contraverſion of the Poles. But Trials ſhewed there was little in any of this.

Thus I would have done with *Split* or *Cleft Wires*; but there is one Thing very ſurprizing, *viz. That the laying one, or the other Side of the Half uppermoſt*, will cauſe a great Alteration in its Tendency, or Averſion to the Poles of the Magnet (as I have ſaid). But if you lay the contrary Side of that Half uppermoſt, the ſame End ſhall be attracted by one, and repelled by the other Pole of the Magnet. In other Pieces, where the Ends are regularly attracted or repelled, only in an inverted Order (as if new touched) if it lay with the round Side uppermoſt at that Time, and be then turned upſide down, *viz.* the flat cleft Side uppermoſt, 'tis ten to one if one of the Ends be not either attracted by both the Poles, or repelled by both; or elſe attracted or repelled by one, and heſitates as to the other. For ſo it often befals.

The Cauſe of this Lubricity of the Magnetiſm, I imagined might be, becauſe the Sides or Edges of the Wire had received contrary Poles by Splitting: And conſequently were turned topſy turvy, that what was the N. might then be the S. Edge of the Half. But I could never diſcover but that the Sides of each End, or of any other Part, were the ſame, when I held the Loadſtone to one or the other Side. Which indeed I always did in every Experiment for greater Certainty Sake.

My Hand being in, I try'd the old Experiment of touching Wires, *by rubbing them backwards and forwards* with one of the Poles of the Loadſtone, becauſe it might probably give ſome Light into the aforementioned ſtrange *Phænomena*.

Mr. *Barlow* was I think the firſt that diſcovered the Error of this Way of Touching, *viz.* That it weakeneth or much hurteth the Touch. This I tryed, and found what is ſaid not only to be true, but alſo that the Reaſon thereof is, *Becauſe the Poles of the Wire, or Needle, ſo touched, are not at the Ends, but in or near the Middle of the Wire or Needle.* Sometimes one is near the Center, the other at one or both Ends. For in ſome Wires ſo touched, both the Ends of the Wire would be attracted by one Pole of the Loadſtone, and repelled by the other: And in ſuch Caſe the repelling Pole always found a ſympathetic Part near the Center of the Wire. In others (eſpecially where a Verticity ſucceeded, as ſometimes it will do, and that pretty ſtrongly too, in ſuch a Caſe) the Verticity would be inverted, and the Ends of the Wire be attracted and repelled in a direct contrary Manner to the Natural Form. And the Reaſon of all this will be manifeſt from theſe following Experiments.

I touched a Wire from End to End with only one Pole of the Magnet: This gave ſo vigorous a Touch, that I am almoſt of Opinion, *It is the beſt Way of Touching.* The Conſequence was, the End where I began

I began always turned contrary to the Pole that touched it. I again touched the ſame Wire, and others too with the other Pole of the Magnet, from the ſame End, and then that End turned the contrary Way, *e.g.* Mark one End of a Wire for the North End, and touch that Wire, by drawing the N. Pole of the Magnet divers Times along the Wire from the N. to the S. End; this Wire, ſo touched, ſhall have a vigorous Verticity, but the North End ſhall ſtand South: But if you touch that, or another Wire, (for it is all one, becauſe the latter deſtroys the former Touch; I ſay, if you touch) by drawing the N. Pole of the Magnet from the S. to the N. End of the Wire, then this N. End will turn N. And ſo it will do the ſame, if you touch with the Southern Pole from the N. to the S.

There is one Experiment more, doth yet give farther Light into what goeth before, *viz.* I touched an Iron Wire exactly in the Middle with only one Pole of the Loadſtone, without drawing it backwards or forwards. The Event was, that in that Place that Pole of the Wire was, and the two Ends were the contrary Pole of the Wire, and were accordingly repelled or attracted by the Poles of the Loadſtone: And the Middle, and an Inch or more on each Side, was attracted by the Pole only that touched it.

If we reflect and compare the foregoing Experiments one with another, they not only illuſtrate one another, but ſeem to lay open a fair Way towards the Diſcovery of a great many of the intricate *Phænomena* of Magneticks.

Experiments concerning the Proportion *of the* Power *of the* Loadſtone *at different* diſtances, *by Mr.* F. Hawkſbee. n. 335. p. 506.

III. 1.] Without mentioning the Difficulties that attend the making of Experiments of this Nature, I ſhall give an Account of their Succeſs.

I took a Quadrant of four Feet Radius, and having fix'd it to the Floor, in the Poſition of the Needle, whoſe South Point directed itſelf to no Degrees, I then fix'd a Board (likewiſe on the Floor) in a direct Angle from the ſame, the Graduations on which Board were 3 Inches diſtant from each other. The Needle was ſuſpended on a Point ariſing from the Center of the Quadrant, from whence were meaſured the ſeveral Stations of the Magnet. The Magnet was laid on a thin Piece of Board, under which, to one Side was nail'd a narrow Slip of Wood, to ſlide it along the Side of the foremention'd graduated Board, whereby the Stone might be always kept in the ſame Direction to the Needle. The Stone that I uſed, weighed about ſix Pounds; was rough, and of an irregular Figure; yet I could diſcover no Inconveniency in the Experiment ariſing from the ſame, it being, and acting at all Diſtances in the ſame Poſition as it is firſt plac'd on the Board: And I ſee no Reaſon to doubt, but the Proportions of its Power will be regular, and agreeable to the ſeveral Diſtances, as more than once I have obſerv'd. For when the Stone hath been differently poſited on the fore-mention'd thin Board, different Angles of the Needle would enſue at the ſame Stations, yet their Proportions one to another would be nearly the ſame. My

meaning is this: Suppoſe the Stone was ſo plac'd, as at 3 Inches from the Needle, it would give the Needle an Angle of 90 Degrees, the Stone being continued in the ſame Direction, at the ſeveral Stations, the Proportions of its Power one to another would be much the ſame, as if the Angle of the Needle at the firſt Beginning made but 87, or even but 80 Degrees on the Quadrant; for upon a ſmall Alteration of the Poles of the Stone, ſuch Diverſity of Angles will ariſe.

In theſe Experiments I made uſe of two Needles, one of a *Radius* of 6 Inches, the other but one Inch; which laſt, after many Trials, I found to be moſt accurate, beſides the Advantage it gave in beginning the Experiment 6 Inches nearer the Stone, than the other; and from two Feet Diſtance from the ſame, it became nearly agreeable to the Angles made by the long Needle to all the farther Diſtances; as you will find by the following Tables, which were made with the ſeveral Needles in the ſame Direction of the Stone. I meaſured the Angles by a Silk Thread ſtrained directly over the Needle to that Part of the Quadrant to which it was directed; which was the beſt Way I could contrive to come neareſt the Truth.

It may be obſerv'd from the following Tables, that the long Needle at 9 Inches from the Stone, made ſomewhat a larger Angle than the ſhort Needle at 3 Inches Diſtance from the ſame; that the ſhort Needle at the Diſtance of 9 Inches, made an Angle of 9 Degrees leſs than the long one at the ſame Place. But this Odds will eaſily be accounted for, if we conſider the Diſproportions of the Needles Lengths; for the Point of the long Needle at 9 Inches, was brought within an Inch as near the Stone, as the Point of the ſhort Needle was, when but 3 Inches diſtant from the ſame: The Point of the ſhort Needle at 9 Inches from the Stone, was 5 Inches farther from it, than the long one at the ſame Station. Theſe Diſproportions being conſider'd, it is no Wonder ſuch Difference of Angles ſhould enſue upon the Uſe of the ſeveral Needles near the Stone; for at two Feet, and the farther Diſtances, they become nearly agreeable, as I ſaid before. When I ſpeak of Diſtances from the Needle, I always mean from the Center of it.

Farther it is obſervable, that the Stone at 5 Feet Diſtance from the Needle made an Angle of 2 Degrees with one, and with the other of two and a half; yet upon the Abſence of the Stone, they would return to no Degrees, as at firſt: Which plainly ſhews, that the Influence of the Stone extended farther; although Obſervations, at remoter Stations, could not eaſily be determined.

At greater Diſtances, and even the more remote in theſe Tables, the Power of the Stone is ſo weak, and the meaſuring the Angles at all Times exactly, ſo difficult, that 'tis well if we come ſometimes within 10 or 20 Minutes of the Truth.

Expe-

Experiments by the ſhort Needle.

Diſtances of the Loadſtone from the Needle in Inches.	The ſeveral Angles of the Needle at the ſeveral Diſtances. D. ′	The differences compared one with another, at the ſeveral Obſervations, in Minutes.
3	87 — 00	180
6	84 — 00	330
9	78 — 30	570
12	69 — 00	735
15	56 — 45	795
18	43 — 30	630
21	33 — 00	540
24	24 — 00	360
27	18 — 00	270
30	13 — 30	150
33	11 — 00	135
36	8 — 45	105
39	7 — 00	90
42	5 — 30	60
45	4 — 30	40
48	3 — 50	30
51	3 — 20	20
54	3 — 00	15
57	2 — 45	15
60	2 — 30	00

Experiments by the long Needle.

Diſtances of the Loadſtone from the Needle in Inches.	The ſeveral Angles of the Needle at the ſeveral Diſtances. D. ′	The differences compared one with another, at the ſeveral Obſervations, in Minutes.
9	87 — 30	345
12	81 — 45	570
15	72 — 15	1137
18	53 — 20	1100
21	35 — 00	660
24	24 — 10	380
27	17 — 50	280
30	13 — 10	180
33	10 — 10	130
36	8 — 00	90
39	6 — 30	75
42	5 — 15	65
45	4 — 10	40
48	3 — 30	30
51	3 — 00	25
54	2 — 35	20
57	2 — 15	15
60	2 — 00	00

The Stone with which theſe Experiments were made, was of this Form, and weigh'd exactly ſix Pound, one Ounce, and a Quarter, Averdupois-Weight. Its Breadth at the North-pole was four Inches, at the South-pole five Inches; the Poles running through the Stone, in the Direction of the prick'd Line. The Length of the ſhorteſt Side was ſix Inches and a Half, and of the longeſt Side ſeven Inches and a Half. Its Thickneſs at the North-pole was one Inch and a Half, and at the South-pole one Inch.

2.] By Order of the *Royal Society*, Mr. *Hawkſbee* and my ſelf made an Experiment with the great Loadſtone belonging to the Society, in order to diſcover the Law of the Magnetical Attraction, an Account of which I gave to the Society, in a Letter to Dr. *Sloane*, dated *June* 25, 1712. Since that, Mr. *Hawsſbee* made another Experiment of the ſame

An Account of an Experiment *to diſcover the* Law *of the* Magnetical Attraction, *by Dr.* B. Taylor. n. 344. p. 294.

ſame Nature with a ſmaller Loadſtone; upon comparing the Numbers of that Experiment with thoſe of the other, I find the Numbers of the firſt Experiment to be very much more regular; wherefore I conclude the firſt Experiment to be the beſt. It was made in the following Manner:

We placed the Great Loadſtone belonging to the *Royal Society* ſo, that its two Poles lay in the plane of the Horizon, and were in a Line exactly at Right Angles with the natural Direction of the Needle we made uſe of (which was, that Dr. *Halley* had made to obſerve the Variations with:) And by means of a Carriage contriv'd for that purpoſe, the Stone was eaſily moved to and fro, the Poles continuing always in the ſame Line. The Needle was ſo placed, that the Center it play'd upon, was in the ſame Line with the poles of the Stone; the North-pole being towards the Needle. We meaſur'd the Diſtances from the Center of the Needle to the Extremity of the Stone: and we found the Variations of the Needle from its natural poſition, to be as in this Table.

Diſt. Feet.	*Variat.*	
1	81	45′
2	58	00
3	30	00
4	16	00
5	9	20
6	5	35
7	3	30
8	2	20
9	1	35

CHAP. V.

Agriculture. Botany.

Of the Manuring *of* Lands *by* Sea-ſhells *in* Ireland, *by the Archbiſhop of* Dublin. n. 314. p. 59.

I. THE Counties of *London-Derry* and *Donegal* in *Ireland*, are very mountainous, and thoſe Mountains covered with Bogs and Heath, inſomuch that there is little Arable Ground in them, except what has lately been made ſo. There are three Ways practiſed to reduce Heath and Bog to Arable Land: The firſt is, by cutting of the Scurf of the Ground, making up the Turf ſo cut in Heaps, and when the Sun has dried theſe Heaps, they are then ſet on *Fire*; when burnt as much as they can be, then thoſe Heaps are ſcattered on the Ground, and it being ploughed, it beareth Barley, Rye, or Oats, for about three Years.

The Inconveniences are, firſt, that ſuch Burning defiles the Air, cauſeth Rain and Wind, is not practical in a wet Summer, and by deſtroying the Sap of the Earth and Roots of the Graſs, and all other Vegetables, renders it uſeleſs for ſeveral Years after the third, in which it is ploughed.

The

The ſecond Way is by *Liming*; this is much better than the former, becauſe it doth not ſo much depauperate the Ground, will laſt long, and beareth better Grain, and whatever is pretended, doth not deſtroy the Graſs, if due Care be taken not to over-plow it; but then this is very dear, and Lime-ſtone is not every where to be had, and in many Places Fire is wanting.

Dung is the common Manure in all Places, and therefore I ſhall ſay nothing of it.

Marl is not uſed, that I have obſerved, in the North, but about the Sea-ſide the great Manure is *Shells:* Any one that will look into the Map, will ſee how the Bay of *London*, commonly called *Loughfoyle*, lies; towards the Eaſtern Part of it there lie ſeveral Eminencies that hardly appear at low Water; theſe are made of Shells of Sea-fiſh of all ſorts, more particularly of Perriwinkle, Cockles, Limpet, *&c.* The Country Men come with Boats at low Water, and carry Loads of theſe Shells away; they leave them in Heaps on the Shore, and there let them lie till they drain and dry, and by that Means become much lighter for Carriage; they carry them by Boats as far as the Rivers will allow them, and then in Sacks on Horſes, perhaps ſix or ſeven Miles into the Country; they allow ſometimes 40, but moſtly 80 Barrels to an Acre; they agree with boggy, heathy, clayey, wet, or ſtiff Land, but not with ſandy. They ſeem to give the Land a ſort of Ferment, as Barm doth to Bread, opening and looſening the Clods, and by that Means making Way for the Roots to penetrate, and the Moiſture to enter into the Fibres of the Roots: The Manure continues ſo long, that I could find none that could determine the Time of its enduring.

The Reaſon of its long Continuance ſeems to be this, that the Shells melt every Year a little, till they be all ſpent, which requires a conſiderable Time, whereas Lime, *&c.* operates all in a Manure at once; but it's to be obſerved, that in ſix or ſeven Years the Ground grows ſo mellow, that the Corn that grows on it becomes rank, and runs out in Straw to ſuch a length, that it can't ſupport itſelf, and then the Land muſt be ſuffered to lie a Year or two, that the Ferment may be a little quieted, and the Clods harden, and then it will bear as long again, and for ought I know and could find, it continues to do ſo with the like Intermiſſions for 20 or 30 Years.

In the Years in which the Land is not plowed, it bears a fine Graſs, mixed with Daiſies in Abundance; and it is pleaſant to ſee a ſteep high Mountain, that a few Years before was all black with Heath, on a ſudden look white with Daiſies and Flowers.

It fines the Graſs, but makes it ſhort, tho' thick. Obſerving that this Manure produced Flowers in the Field, I made my Gardener uſe theſe Shells in my Flower-Garden, and never ſaw better Carnations, or Flowers fairer or larger than in that cold Climate; and it contributes to deſtroy Weeds, at leaſt doth not produce them ſo much as Dung; it likewiſe produces very good Potatoes at about a Foot Diſtance from one Potatoes.

one another; and this is a Method of reducing boggy barren Land. They lay a little Dung or Straw on the Land, and ſprinkle it with Shells; ſometimes they cut the Potatoes, if large, that they may go the further, and then dig Trenches about ſix or ſeven Foot Diſtance, and throw the Earth or Soil, they take out of them, on the Potatoes, ſo as to cover them, and then fencing the Plot of Ground ſo planted, let them grow. Plant them in *April* or *May*, and they are ripe in *Auguſt*; they dig them as they have Occaſion, and let them lie till next Year, then dig them again, and ſo the third Year; every Year they by this Means go deeper in the Earth, and the laſt they dig them, then pick them out as carefully as they can, that little Seed may remain; and the fourth Year they plow the Ground, and ſow Barley, and the Produce is very good for ſome Years. Some Potatoes will remain and grow up without any Hurt to the Barley or Oats; and thoſe they dig and pick out, and the Ground remains good and arable ever after.

'Tis obſervable, that Shells do beſt in boggy Ground, where the Surface is Turf; Turf generally is nothing but the Product of Vegetables, ſuch as Graſs, Heath, *&c.* that being rotten, the Salt is waſhed away by the Water, and there remains only the earthy, and eſpecially the ſulphureous Parts of them, as appears from the Inflammability of Turf; now Shells being chiefly a Salt, it incorporates with the Sulphur of the Plants, and renders them fit for the Vegetation of new Plants.

And this appears further from this, that Shells that have been under the Salt Water are much better than ſuch as have been in the Earth, to dry at the Strands: Almoſt about the Bay of *Londonderry*, if you dig a Foot or two, it yields Shells, and whole Banks are made up of them; but theſe, tho' more intire than ſuch as are brought out of the Shell Iſland, are not ſo profitable for Manure.

I obſerved in a Place near *Newtown Lamavady*, about two Miles from the Sea, a Bed of Shells, ſuch as lie on the Strand; the Place was cover'd with a Scurf of wet ſpouty Earth, about a Foot thick; the Country People uſed the Shells, but they were not reckon'd ſo good as thoſe that are found in the Sea or near it.

The Land about the Sea-ſide bears very indifferent Wheat, nor will the Shells do in that Particular, without ſome Dung; but I very much doubt, whether that be not due to the Ignorance of the Farmers, that generally underſtand nothing of Wheat.

Some Thouſands of Acres have been improved by the Shells, and that which formerly was not worth a Groat *per* Acre, is now worth four Shillings: They have in many Places thus improved the very Mountains, that before were very Turf Bogs. In theſe they meet with this Inconveniency, that if the Seaſon for Plowing proves wet, their Horſes ſink ſo deep in the Soil, that they can't plow it, eſpecially after two or three Years.

They commonly made Lime of the Shells formerly, and ſome do ſo ſtill. I have not, that I remember, ſeen any ſuch Lime, but I underſtood that it bound very well, and I believe it is not ſo corroſive as Lime made of Stone; for I find, in the Hiſtory of *Ceylan*, that they make up their Land with Lime of Oyſter-Shells, and which I believe would be impracticable with Common Lime.

About 30 Years ago they made Lime of the Shells, and manur'd their Lands with it; but a poor Countryman, that, out of Lazineſs or Poverty, had not provided to make Lime, threw the Shells unburnt on his Land; his Crop prov'd as good as his Neighbours, and the ſecond and third Crop better, and all took the Hint, and have uſed them ſo ever ſince.

Where Shells are not to be procur'd, Sea-Rack or Sand ſupply the Want of them, but are not ſo good; Sea-Rack laſts but three Years, and Sand little longer.

'Tis certain, *Ireland* has been better inhabited than it is at preſent: Mountains that now are cover'd with Bogs, have formerly been plow'd; for when you dig five or ſix Feet deep, you diſcover a proper Soil for Vegetables, and find it plow'd into Ridges and Furrows. This is obſervable in the wild Mountains between *Ardmagh* and *Dundalk*, where the Redoubt is built, and likewiſe on the Mountains of *Altmore:* The ſame, as I am inform'd, has been obſerv'd in the County of *London Derry*, and *Donegal*; a Plow was found in a very deep Bog in the latter, and a Hedge with Wattles ſtanding under a Bog that was five or ſix Feet deep above it. I have ſeen the Stump of a large Tree in a Bog, ten Feet deep at *Caſtle Forbes*; the Trunk had been burnt, and ſome of the Cinders and Aſhes lay ſtill on the Stump. I have ſeen likewiſe large old Oaks grow on Land, that had the Remains of Ridges and Furrows: And I am told, that on the Top of a high Mountain in the North, there are yet remaining the Streets and Footſteps of a large Town; and indeed there are but few Places, which do not viſibly (when the Bog is remov'd) retain Marks of the Plow; which ſure muſt prove, that the Country was well inhabited. It's likely that the *Danes* firſt, and then the *Engliſh*, deſtroy'd the People; and the old Woods ſeem to thoſe that pretend to judge, to be about three or four hundred Years ſtanding, which was near the Time that *Courcey* and the *Engliſh* ſubdued the North of *Ireland*, and 'tis likely made Havock of the People, that remain'd after the *Danes* were beat out of *Ireland*.

II. The Burning of the Surface of the Land is ſo much practis'd in *Devonſhire*, that 'tis elſewhere known by the Name of *Devonſhiring*; but it is uſed only for bad Lands, and by worſe Huſbands, for it robs the Ground.

Of the Manuring *of* Land *by* Sea-Sand *in* Devonſhire, *by Dr.* A. Bury. n. 316. p. 142.

Salt quickens dead Land, and is uſed in the South Weſt Part of the Country, which would elſe be the barrenneſt, but is now the richeſt Part of it. They go as far as the Sea will permit them, at the loweſt Ebb,

and take the Sand in Bags; and carry it on Horſeback 14 Miles into the Country, and ſpread it upon the Land, and thereby improve it both for Corn and Graſs. In other Parts they force their barren Land, by mingling the Earth with Lime, and caſting it upon the Ground.

In this they differ, that Crude and Single *Salt*, if ſtrew'd upon the Ground, does not improve, but corrode it; but *Lime*, tho' unmingled, betters it: But in this they agree, that they produce not Graſs fit for the Scythe, but for Paſture, ſhort and ſweet, and which grows all the Winter; ſo that their Sheep know not either Hay or Water, nor are their higheſt Grounds parch'd by the Sun in the hotteſt Summer. The beſt Way is, to mix theſe Male and Female Salts; for the Sea Salt is too luſty and active of itſelf; the Lime has a more Balſamic, but gentler Salt, and regularly join'd with the other, is thereby invigorated. How to mix thoſe two, *Glauber* thus directs: *Take* (ſays he) *Quick-Lime, let it ſlack by Time without Water; then take Salt and Water, mingle them together, and make them into Balls or Pieces, which you pleaſe; dry them as you do Bricks, then burn them for about two Hours; this Compoſt will enrich the pooreſt Land.*

Thoſe who are much devoted to Agriculture, ſhould chuſe ſuch a Situation for a Dwelling, as is beſt accommodated with Lime, Salt, and Coals; and if our Gentry underſtood this Huſbandry, they would ſo far free Salt from its Tax, as it ſhould be employ'd on Land, which is not intended to pay for it.

Obſervations *relating to the* Motion *of the* Sap *in* Vegetables, *by Mr.* R. Bradley. n. 349. p. 486.

III. It may in general be obſerv'd of *Plants*, that they are either *Terreſtrial*, *Amphibious*, or *Aquatic*; and ſo nearly do Vegetables agree with Animals in moſt Points, except Local Motion and its Conſequences, that from the Knowledge of the one we are reaſonably led to the Diſcovery of the other.

Thoſe Plants, which I call *Terreſtrial*, are ſuch as *Trees*, *Shrubs*, and *Herbs*, which grow only on the Land. Theſe like Land-Animals have Diverſities of Food, a Method of Generating, and certain Periods of Life.

Of the *Amphibious* Race, which live on Land as well as in the Waters, are the *Willows*, *Ruſhes*, *Mints*, &c. Theſe are not unlike in many Reſpects to the *Otter*, *Tortoiſe*, *Frog*, &c.

The *Aquatics*, whether of *Lakes*, *Rivers*, or the *Sea*, are very numerous: Theſe may be compar'd with the *Fiſh-kind*, and will not live out of their proper Elements. In *Freſh Waters* are the *Water-Lillies*, *Plantains*, &c. and in the *Sea*, *Corals*, *Fuci*, &c.

Plants ſeem to poſſeſs only the next Degree of Life below the moſt ſtupid *Animal*; or where Animal Life leaves off, the Vegetable Life ſeems to begin.

The Seaſons of Motion in *Plants* are the ſame with thoſe of *Animals*, which ſleep during the Winter. An Artificial Heat will give Motion to either of theſe in the coldeſt Time.

The

The common Opinions relating to the *Sap*'s Motion, are as follows: Firſt, the *Sap* does not riſe by the *Pith*; becauſe ſome have obſerv'd the Trunks of large Trees to be without that Part, and yet the ſame Trees have continued to put forth Fruit and Branches on their Tops. I have obſerv'd, that the *Pith* is not found in thoſe Branches of a Tree, which exceed two or three Years Growth; and it is certain, that the *Pith*, which is in a Branch of this Year, will (the greateſt Part of it) be diſtributed into thoſe Boughs, which form themſelves the next Seaſon.

It is ſaid by ſome, that the Tree does not receive its Nouriſhment by the *Bark*, for that Trees having loſt that Part, will ſtill continue their Growth. Others tell us, that if the *Bark* be cut away round the Trunk of a Tree, it will preſently die. Theſe various Opinions ſeem to have been ſet on Foot without extraordinary Conſideration, upon the Belief, that a Tree has but one *Bark*; whereas, upon Examination with the Microſcope, we find four diſtinct Coverings to each Branch, without the woody Parts. The two outermoſt *Barks* may be taken from a Tree without great Damage, but the other two, which lie nearer the Wood, being ſtripp'd off, will kill the Tree.

Some affirm, that the *Sap* doth neither riſe nor fall in the woody Part of the Tree, becauſe they have not been able to diſcern any *Sap* to iſſue out of that Part when a Branch has been cut. The Microſcope plainly ſhews us the Veſſels in the Wood, through which the *Sap* riſeth from the Root; but as theſe Tubes are not large enough to admit into them any Thing more groſs than Vapour, ſo they have not been eſteem'd to be of any great Uſe. The Explanation of *Figure* 47. will in ſome meaſure diſcover the Office of theſe and of ſuch other Parts of a *Plant*, as are ſeverally deſign'd for the Growth of Vegetables; but firſt let us enquire a little into the Nature of the *Root*.

The *Root* of a Tree is chiefly compoſed of a *Parenchyma*, more groſs than that in the Stem or Body of the Tree; it has likewiſe Veſſels and a Covering. The Root, that is, the principal Part of it, receives into it ſuch Juices of the Earth, as are proper for it, and no other. Somewhat like a Wiek of Cotton, which having been impregnated with Oil, will only admit Oil into it. This Proviſion being made in the *Stomach* of the *Plant* (as I call it) chiefly in the Autumn Months, the Tree is prepared for Germination, ſo ſoon as the Earth is ſufficiently warm'd, either by the Sun's Beams, or an artificial Heat, ſuch as Horſe-dung, Bran and Water, or other ſuch like Ferments. Theſe Heats raiſe into Vapour the Juices contained in the Root, and by that Means cauſe Vegetation.

Figure 47. is part of the Branch of an *Apple Tree* made in *May* 1715, and cut in *April* 1716. It was cut in Figure of a half Cylinder, the length ſomewhat more than the Diameter, which was about a Quarter of an Inch. This being magnified with one of *Campani*'s Microſcopes, diſcovers the following Parts, *viz.* Fig. 47.

1, 2, 3, 4, 5, 6, 7, Are Capillary Veſſels, which run longitudinally through the Branch, in the ligneous part, which was made in the Year 1715. Through theſe Tubes, the Steam riſeth from the Root, the Strength of which is well explain'd by the Engine for raiſing Water by Fire, invented by the late Captain *Savery*.

From A to B, we may view Veſſels of the ſame ſort, made at the ſame Time.

8, 9, Are Veſſels of the ſame Uſe with the former, now forming themſelves for the Uſe of the Year 1716.

By this Means the Diameter of the Branch is increas'd, and additional Nouriſhment ſuffer'd to paſs into thoſe Buds, which are to make new Branches. Theſe are made out of the fourth or innermoſt Bark, mark'd C, C.

The Mouths of the Capillary Tubes of the Years 1715, and 1716, are D, E. The Vapour which riſeth from the Root, is continued in theſe Veſſels, to the Extremities of the Branches, where it meets with Parts (not here deſcrib'd) like to *Glands*; which *Glands*, if we may ſo call them, are likewiſe found at every Knot or Joint. At theſe places, the Vapour coming near the Air, is condenſed, and returns between the Barks, by means of its own Weight, down F, G, H, leaving in each Bark mark'd I, K, L, ſuch Juices as each of them naturally is inclin'd to ſeparate from it; till at laſt, the more oily part paſſing to the Root, may lengthen the *Fibres* thereof, as Icicles are lengthened; and by its oleous Particles, preſerve them from rotting by the Wet. The parts which compoſe the ſeveral Barks, are *Parenchymous* or *Spungy*.

The firſt mark'd M, is of a cloſer Texture than the ſecond N, and the ſecond cloſer than the third O, and ſo on till theſe parenchymous parts are interwoven with the longitudinal Wood-Veſſels, where they are ſomewhat conſtrain'd, till they come to make the Pith, mark'd P. Then they are much larger than in any other part of the Tree; and by what I have obſerv'd, ſeem to contain a more finiſh'd Juice than the reſt, and may well enough be ſtiled the *Medulla*.

We may note, that when the fourth or innermoſt Bark C, has once compleated its Sap-Veſſels, and is firmly join'd to the wooden part, then the third Bark O, takes its place for the ſucceeding Year; and ſo the reſt, except that the firſt, mark'd M, ſplits and divides itſelf, to ſupply the place of the ſecond.

The following Enquiry I recommend to the Curious, *viz.* If the ſeveral Barks, having different Texture of parts, admit into each ſeparate and different Juices from the reſt; whether thoſe Juices may not be of very different Virtues; the firſt more *Aſtringent* than the others, the ſecond perhaps *Emetick*; and the third *Cathartick*.

IV. The

IV. The nice and curious Texture of the *Flower* in Plants, and its Furniture, has employ'd the Enquiries of many Learned Men. But ſince theſe Searchers into the Hiſtory and Operations of Nature, ſeem not ſo ſucceſsfully to have reach'd her Deſign in this Caſe, as in many others, I ſhall attempt to account for the Fabric and Uſe of theſe Parts, and to make the Propagation of Vegetables more intelligible, whereby the Ways of Nature will appear more harmonious, and of a piece.

Some new Obſervations *on the* Parts *and* Uſe *of the* Flower *in* Plants, *by Mr.* S. Moreland. n. 287. p. 1474.

It has been long ago obſerv'd, that there is in every particular Seed a Seminal Plant, conveniently lodg'd between the two Lobes, which conſtitute the Bulk of the Seed, and are deſign'd for the firſt Nouriſhment of this tender Plant.

Dr. *Grew* is the only Author I can find, who has obſerv'd that the *Farina* (or fine Powder which is at its proper Seaſon ſhed out of thoſe *Thecæ* or *Apices Seminiformes*, which grow at the Top of the *Stamina*) doth ſome Way perform the Office of Male Sperm. But herein I think he falls ſhort, in that he ſuppoſes them only to drop upon the outſide of the *Uterus* or *Vaſculum Seminale*, and to impregnate the included Seed by ſome ſpirituous Emanations or energetical Impreſs.

That which is now ſubjected to Enquiry, is, whether it be not more proper to ſuppoſe, that the Seeds which come up in their proper *Involucra*, are at firſt like unimpregnated *Ova* of Animals; that this *Farina* is a *Congeries* of Seminal Plants, one of which muſt be convey'd into every *Ovum* before it can become prolifick; that the *Stylus* in Mr. *Ray*'s Language, the upper part of the *Piſtillum* in Mr. *Tournefort*'s, is a Tube deſign'd to convey theſe Seminal Plants into their Neſt in the *Ova*; that there is ſo vaſt a Proviſion made, becauſe of the Odds there are, whether one of ſo many ſhall ever find its Way into, and through ſo narrow a Conveyance.

To make this Suppoſition the more credible, I ſhall lay down the Obſervations I have made upon the Situation of theſe *Stamina* and the *Stylus* in ſome few Species of Plants.

Firſt, in the *Corona Imperialis*, where the *Uterus* or *Vaſculum ſeminale* of the Plant ſtands upon the Center of the Flower, and from the Top of this ariſeth the *Stylus*, the *Vaſculum ſeminale* and *Stylus* together repreſenting a *Piſtillum*. Round this are planted ſix *Stamina*, upon the Ends of each of theſe are *Apices*, ſo artfully fixt, that they turn every Way with the leaſt Wind, being in Heighth almoſt exactly equal to the *Stylus* about which they play, and which in this Plant is manifeſtly open at the Top, as it is hollow all the Way. To which we muſt add, that upon the Top of the *Stylus* there is a ſort of *Tuft*, conſiſting of pinguid *Villi*, which I imagine to be plac'd there, to catch and detain the *Farina*, as it flies out of its *Thecæ*. From hence I ſuppoſe the Rain either waſhes it, or the Wind ſhakes it down the Tube, till it reach the *Vaſculum ſeminale*.

In *Capri-folium*, or *Honey-ſuckle*, there riſes a *Stylus* from the rudiments of a Berry, into which it is inſerted to the Top of the *Monopetalous* Flower, from

from the Middle of which Flower, are ſent forth ſeveral *Stamina*, that ſhed their *Farina* out of the Caſes upon the Orifice of the *Stylus*, which in this Plant is villous or tufted, upon the ſame Account as the former.

In *Allium* or *common Garlick*, there ariſes a *Tricoccous Uterus*, or Seed-Veſſel, in the Center of which, is inſerted a ſhort *Stylus*, not reaching ſo high as the *Apices*, which thus over-topping it, have the Opportunity of ſhedding their Globules into its Orifice more eaſily. For which Reaſon I can diſcern no Tuft upon this (as in the former) to enſure their Entrance, that being provided for by its Situation juſt under them.

I ſhall now make ſuch Reaſonings or Reflections as the foregoing Account doth ſuggeſt, and will ſupport.

Nothing can be more natural than to conclude, that where a fine *Powder* is curiouſly prepared, carefully repoſited, and ſhed abroad at a peculiar Seaſon, where there is a Tube ſo planted, as to be fit to receive it, and ſuch Care in diſpoſing this Tube, that where it doth not lie directly under the Caſes that ſhed the Powder, it hath a particular *Apparatus* at the End to enſure its Entrance: Nothing can be more genuinely deduced from any Premiſes, than from this it may, that this *Powder* or ſome of it was deſigned to enter this Tube. If theſe *Stamina* had been only excretory Ducts, as has been hitherto ſuppoſed, to ſeparate the groſſer Parts, and leave the Juice deſigned for the Nouriſhment of the Seed more reſerved, what need was there to lodge theſe Excrements in ſuch curious Repoſitories? They would have been conveyed any where, rather than where there was ſo much Danger of their dropping into the *Seed Veſſel* again, as they are here.

Again, the *Tube* over the Mouth of which they are ſhed, and into which they enter, leads always directly into the *Seed Veſſel*.

To which we muſt add, that the *Tube* always begins to die, when theſe *Thecæ* are empty'd of their Contents; if they laſt any longer, it is only whilſt the *Globules* which enter at their Orifice, may be ſuppoſed to have finiſhed their Paſſage. Now can we well expect a more convincing Proof of theſe *Tubes* being deſigned to convey theſe *Globules*, than that they wither when there are not more *Globules* to convey?

If I could ſhow that the *Ova*, or unimpregnated Seed, are ever to be obſerved without this *Seminal Plant*, the Proof would ariſe to a Demonſtration; but having not been ſo happy as to diſcern this, I recommend the Enquiry to thoſe who are Maſters of the beſt Microſcopes. Though, in the mean Time, I have made ſome Steps towards a Proof of this Sort, and have met with ſome ſuch Hints as make me not deſpair of being able to do it: For, not to inſiſt upon this, that the *Seminal Plant* always lies in that Part of the Seed, which is neareſt to the Inſertion of this *Stylus*, or ſome Propagation of it into the *Seed Veſſel*; I have diſcovered in *Beans*, and *Peaſe*, and *Phaſeoli*, juſt under one End of that we call the *Eye*, a manifeſt Perforation (diſcernible by the groſſer ſort of Magnifying Glaſſes) which leads directly to the *Seminal Plant*, and at which I ſuppoſe the *Seminal Plant* did enter; and

I am

I am apt to think, that the Beans or Peas which do not thrive, will be found deſtitute of it.

I ſhall now deſcribe ſome other Plants, whereby it will appear, that there is a particular Care always exerciſed to convey this Powder into a *Tube*, which may convey it to the *Ova*. Now in *Leguminous* Plants, if we carefully take off the *Petala* of the Flower, we ſhall diſcover the *Pod* or *Siliqua* cloſely covered with an involving Membrane, which about the Top ſeparates into many *Stamina*, each fraught with its Quantity of *Farina*, and theſe *Stamina* are cloſe bound upon the *Bruſh*, which is obſervable at the End of that *Tube*, which here alſo leads directly to the *Pod:* It ſtands not upright indeed, but ſo bended, as to make near a right Angle with it.

In *Roſes* there ſtands a *Column*, conſiſting of many *Tubes* cloſely clung together, though eaſily ſeparable, each leading to their particular Cell, the *Stamina* in a great Number planted all round about. In *Tithymalus*, or *Spurge*, there riſes a *Tricoccous* Veſſel, that whilſt it is ſmall and not eaſily diſcernible, lies at the Bottom till impregnated, but afterwards grows up, and ſtands ſo high upon a tall *Pedicle* of its own, as would incline one to think that there were to be no Communication betwixt this and the *Apices*, which he ſees dying below.

In *Straw-berries* and *Raſp-berries*, the Hairs which grew upon the ripe Fruit (which I ſuppoſe may be ſurprizing to ſome) are ſo many *Tubes* leading each to their particular Seed, and therefore we may obſerve, that in the firſt opening of the Flower, there ſtands a Ring of *Stamina* within the *Petala*, and the whole inward *Area* appears like a little Wood of theſe Hairs or Pulp, which when they have received and conveyed their *Globules*, the Seeds ſwell and riſe in a carneous Pulp.

I have obſerved, and can deduce the Contrivance and Adminiſtration of the Parts in all the Plants I have obſerved, and I doubt not but others may be able to perfect what I have rudely hinted; and that from this Theory many Corollaries may be derived, which will let in Light into many Parts of Natural Philoſophy. I ſhall at preſent only ſuggeſt, that hence one would conclude, that the *Petala* of the Flower were rather deſigned to ſever ſuperfluous Juices, from what was left to aſcend in the *Stamina*, than the *Stamina* to perform this Office, either for them, or the unimpregnated *Semina*; and obſerve the Analogy between *Animal* and *Vegetable* Generation, as far as was neceſſary, there ſhould be an Agreement between them.

The Explication of the Figures.] *Fig.* 48. repreſents a *yellow Lilly*. *A* the Top of the *Piſtillum* or Tube, at which the *Seminal Plants* are ſuppoſed to enter, and through which they are conveyed to the unimpregnated *Seed* in the *Seed Veſſel*. Fig. 48.

b, *b*, *b*, *b*, *b*, *b*, the *Apices Seminiformes*, which when they are ripe open, and ſhed that *Powder* which enters the *Tube* at *A*.

C, the Place of the *Seed Veſſel* at the Bottom of the *Tube*, the Seed-Veſſel itſelf being concealed under the Leaf in this Draught.

Fig.

Fig. 49. *Fig.* 49. *D*, the *Siliqua* in a Flower of the *Pea-kind.*
E, the *Tube* which ariſes from the *Siliqua*, and conveys the *Plants* to it.
F, the *Membranous* Coat that involves the *Siliqua* laid open.
g, *g*, *g*, *g*, *g*, *g*, the *Apices*, which, before the Membranous Tegument is laid open, appear to riſe from its Edges, and by the *Petala* of the Flower, are kept cloſe upon the *Orifice* of the *Tube*, that they may conveniently ſhed their *Farina* into it.

Fig. 50. *Fig.* 50. A *French-Bean* repreſented ſidewiſe.

Fig. 51. *Fig.* 51. The ſame opened.
h, The Seminal Plant.
i, A Perforation, at which, 'tis ſuppoſed, the Seminal Plant firſt enter'd.

Of the Quick Propagation of Moldineſs, &c. in a Melon, *by Mr.* R. Bradley. n. 349. p. 490.

V. I had lately a large Melon-Fruit, which I ſplit lengthways thro' the Middlle, in order to obſerve the Veſſels which compoſed the Membrane or Tunic of each Ovary; but not continuing the Work I had begun, I laid by one half of the Melon, to be examined when I might have more Leiſure.

At the End of four Days, I found ſeveral Spots of Moldineſs began to appear on the fleſhy Part of the Fruit, ſomewhat Green towards the Rind; and of a paler Colour towards the Middle of the Fruit. Theſe Spots grew larger every Hour, for the Space of five Days; at which Time the whole Fruit was quite covered.

This ſurprizing Vegetation made me curious to examine if there was any Difference between thoſe Parts which were Green and the others, beſides their Colour. The firſt being ſeen with the Microſcope, appear'd to be a *Fungus*, whoſe Cap was filled with little Seeds, to the Number of about five Hundred; which ſhed themſelves in two Minutes after they had been in the Glaſſes.

Fig. 52.

The other Sort had many Graſs-like Leaves, among which appeared ſome Stalks with Fruit on their Top, each Plant might well enough be compared to a ſort of *Bull-Ruſh*. They had their Seed in great Quantities, which I believe were not longer than three Hours before they began to vegetate; and it was about ſix Hours more, before the Plants were wholly perfected: For, about ſeven of the Clock one Morning, I found three Plants at ſome Diſtance from any others; and about four the ſame Day, I could diſcern above five Hundred more growing in a Cluſter with them, which I ſuppoſed were Seedling Plants of that Day. The Seed of all theſe were then ripe and falling.

Fig. 53.

When the whole Fruit had been thus cover'd with Mold for ſix Days, this vegetable Quality began to abate, and was entirely gone in two Days more. Then was the Fruit putrified, and its fleſhy Parts now yielded no more than a ſtinking Water, which began to have a gentle Motion on its Surface, that continued for two Days without any other Appearance. I found then ſeveral ſmall Maggots to move in it, which grew for the Space of ſix Days; after which they laid themſelves up

Fig. 54.

in

in their Bags. Thus they remain'd for two Days more without Motion, and then came forth in the Shape of Flies. The Water at that Time was all gone, and there remained no more of the Fruit than the Seeds, the Veſſels which compoſed the Tunics of the Ovaries, the outward Rind, and the Excrement of the Maggots; all which together weighed about an Ounce. So that there was loſt of the firſt Weight of the Fruit when it was cut, about twenty Ounces. Fig. 55.

We may judge from this, and other Caſes of the like Nature, how much vegetable Life is dependent on Fermentation, and animal Life on Putrefaction.

VI. To prepare Land for *Canary Seed*, let it be broke up ſome Time in *April*, and ploughed again about *Midſummer*, and ploughed again in *Auguſt*, that by frequent Tillage the Weeds may be burnt up, and deſtroyed. Plough the laſt Time about the latter End of *February*, or the Beginning of *March*, if the Seaſon proves dry; if not, you had beſt wait for a dry Seaſon; for in ſuch a Seaſon only will the Ground be fit to receive the Seed. With a Hoe, (that has a Bit about the Bigneſs of an Onion-Hoe) you muſt from Time to Time carefully cut up the Weeds. If they are not kept entirely under, much of the Seed will be loſt for Want of ripening. In very good Land half a Buſhel of Seed will be enough to ſow an Acre. It will thrive beſt upon a ſtiff Clay: It will grow upon any ſort of Loamy Land, that is rich enough to bear Hemp. If you apprehend that the Land is not ſufficiently ſtrong, you will do well to allow from half a Buſhel to ſeven Gallons of Seed to ſow an Acre with. *Of the* Huſbandry *of* Canary Seed. *by Mr.* E. Teniſon. n. 337. p. 91.

The Seed is ripe ſooner or later, according as the Spring affords you an early or late Seaſon of ſowing it. In ſome Summers 'tis cut in *Auguſt*, but the moſt uſual Time is after Wheat-Harveſt. When it is cut it muſt in moſt Years lie five or ſix Days in ſwarth, and then be turn'd, and lie till one Side is dryed and rotted as much as the other, which may be about four or five Days longer. The certain Number of Days cannot be fixed, becauſe they muſt be more or leſs, according as the Weather proves fair or rainy.

The Reaſon of its lying ſo long in ſwarth is, that the lower Heads of the Seed (being expoſed to the Air, Wind and Sun) may the better perfect their Ripeneſs, and the Graſs and Weeds that ſprung up with the Stalks be thoroughly withered, and the Ears or Heads well and ſufficiently rotted, and that the Seed upon threſhing may come out clean.

The Produce upon Land that is very good, is about ſix Quarters *per* Acre.

If the Land be but indifferent, or if the Weeds be not kept under, then from four to five Quarters upon an Acre, is as much as you can expect.

The Price of Seed is, from two Pounds to ſix Pounds *per* Quarter; but the moſt uſual Price is from forty Shillings to three Pounds.

It is difficult to threſh. So much of the Seed as, after threſhing, is beaten out (as ſoon as 'tis fanned) is to be run through a Wire-Sieve (ſuch as is uſed to ſeparate Cockle from Corn) and the Huſks of every ſifting, that will not paſs through the Sieve, are to be thrown by in a Heap to be threſhed over again.

The ordinary Price for threſhing is Five Shillings, but in ſome Years the Threſher has Six Shillings *per* Quarter.

Experiments *on* Vegetation, *by Mr.* Abr. de la Pryme. n. 281. p. 1214.

VII. Some have made Experiments of the Meliorating, Fertilizing, and Multiplying of Grain, by ſteeping them in divers Liquors. *Digby* ſomewhere mentions, a Plant of Barley all riſing from one Corn, that by Steeping and Watering with Salt Petre diſſolved in Water, brought forth 249 Stalks, and above 18000 Grains. And the laſt Edition of *Cambden* mentions a Thing very obſervable, that the Corn ſown in a Field in *Cornwall*, after a great Battle in the Civil War Time, brought forth four or five Ears on every Stalk. I have try'd ſome ſuch like Experiments on ſeveral Grains, and though the Encreaſe was not ſuch as I expected, I communicate them to you.

On the 22*d* of *March*, 1699, I laid to ſteep a Pea, a Barley-Corn, and a Wheat-Corn in Brimſtone Water.

A Pea, a Wheat, a Barley, and an Oat-Corn, in Allum-Water, and the ſame in an old Diſſolution of Salt of Tartar, in the *Caput Mortuum* of *Sal Armoniac* diſſolved in Urine, in a Diſſolution of the Salt of Walls, in a Diſſolution of Salt-Petre, in a Diſſolution of *Noſtoc* or Star-Gelly, and in Urine.

I ſteeped them thus five Days and five Nights, and ſet them in a Garden in a good Soil, againſt a North Wall full in the Sun, on the 27*th* of the ſame Month after a rainy Night, with a Pea, a Wheat, a Barley, and an Oat Corn unſteep'd.

Upon the 10*th* of *April* following, I found that ſome were juſt come up, ſome not.

The Pea, the Barley, and the Wheat ſteeped in Brimſtone-Water came all up together.

The Pea ſteeped in Allum-Water was very big and ſwelled, but not ſo much as ſprouted, but the Barley, Wheat, and Oat above Ground.

The Pea ſteeped in the old Solution of Salt of Tartar, was half come up, the Wheat ſcarce ſprouted, but the Barley and Oat quite up.

The Pea, the Wheat, the Barley, and the Oat ſteep'd in the *Caput Mortuum* of *Sal Armoniac* diſſolv'd in Urine were all up together; as were alſo the next Row, that were ſteep'd in the Solution of Salt of Walls.

The Pea and Wheat ſteep'd in the Diſſolution of Salt-Petre were about half up, but the Barley and Oat quite up.

Thoſe

Thoſe which were ſteep'd in *Noſtoc*, were none of them come up, nor ſcarce ſprouted.

The Barley and Oat ſteep'd in Urine, were come up, but the Pea and Wheat ſcarce ſprouted.

And, to my Surprize, the Pea, Wheat, Barley, and Oat, that were not at all ſteep'd, were all of them as ſoon up as any of the former, except only the Wheat, which was about half up.

I ſet them all about a Finger deep in the Ground, and there was all the Time of their Growth very fine Weather.

From all which I ſuppoſe, that Allum-Water is againſt the Nature of Peas, and retards their Growth, but agrees well enough with Wheat, Barley, and Oats.

That the Solution of Salt of Tartar is not friendly to the Nature either of Peas or Wheat, but agreeable to the Nature of Oats and Barley.

That the Water of Salt-Petre had not any of the great Power or Virtue that I ſuſpected, *&c.*

And that theſe Steepings did not further any of the ſaid Grains in their Growth and Coming, but plainly retarded ſome or moſt of them.

Then I digg'd all of them up, but three Spires of Barley, which I let ſtand about a Foot and a half, or two Foot, from one another; which grew and increaſed ſo exceedingly, that they had ſixty, ſixty-five, and ſixty-ſeven Stalks a-piece, from their ſingle Grain and Root, with every one an Ear on, and about forty or ſomewhat more Corns a-piece in them; which Increaſe proceeded not ſo much perhaps from the Grain having been ſteep'd in any Liquors, as from the Fertility and Goodneſs of the Soil, and their competent Diſtance one from another. I obſerved that new Shoots continually ſtruck up from the Root; and that as in the *Eaſt* and *Weſt-Indies*, there are Trees that always bear Bloſſoms and Flowers, green and ripe Fruit at the ſame Time, ſo that here, if the invigorating Heat of the Sun had not been cool'd and weaken'd by the Approach of the Winter-Seaſon, there would have been continually new, ripe Corn, and empty Ears, on the ſame Root.

Of the Great *and Speedy* Vegetation *of* Turnips. *Communicated by Dr.* J. T. Deſaguliers. n. 360. p. 974.

VIII. At *Sutton-Coldfield* in *Warwickſhire*, a peaty Ground near a Pool (of which it was formerly a Part) was ſown with *Turnip-Seed* on the 2*d* Day of *July* 1702. In leſs than three Days Time the Turnips were ſeen above Ground. At three Weeks End the Roots were in Bigneſs equal to Walnuts. Within leſs than five Weeks after the Sowing, the Gardener drew great Quantities of Turnips to ſell, they then being as big as large Apples. At the End of ſix Weeks, *viz.* on the 12*th* Day of *Auguſt*, a large Turnip was plucked up (though probably not ſo big as ſeveral others then growing upon the ſame Ground) which, together with its Top and long deſcending Part of the Root, weighed above two Pounds and fourteen Ounces. At the ſame Time alſo was weighed an Ounce of the ſame Sort of Turnip-Seed, that the Gardener had ſown his Ground with; and afterwards a thouſand of the Grains were

counted ſingly out of the Ounce ſo weighed; and the reſt of the Ounce was divided into Heaps, as near as could be gueſſed, equal to the 1000 Seeds firſt ſevered and laid together: And it was found, that the whole Ounce contained above 14600 ſingle Grains; which Number multiplied by 46 (*viz.* the Number of Ounces that the Turnip weighed) produced 671600, *viz.* the Number of ſingle Grains of Seed required to equal the Weight of the Turnip. From whence may be gathered, that (upon Suppoſition that the Increaſe of the Turnip was all along uniform and equal, from the Time it was ſown, till it was pluck'd up) the Grain of Seed which it ſprung from, weighing when it was ſown but $\frac{1}{14600}$ of an Ounce, was increas'd in Weight according to the following Proportions, *viz.*

In ſix Weeks Time	671600		Times its own Weight.
Every Week	111933	$\frac{1}{2}$	
Every Day	15990	$\frac{1}{2}$	
Every Hour	666	$\frac{1}{4}$	
Every Minute of an Hour	11		

Some Days after another Ounce of the ſame Sort of Seed was exactly weighed, and the Grains were found to be in Number 14673.

Another Turnip of the ſame Crop was pluck'd up on the 21*ſt* of *October*, and was found to weigh above 10 Pounds and a half, which unuſual and wonderful Bulk it acquir'd (it being ſuppoſed as above that the Growth was all alike) by increaſing the Weight of the Seed it was raiſed from, 15 Times in every Minute of an Hour, from the ſowing to the drawing of it.

The Gardener neglected to thin his Turnips in due Time, elſe probably their Growth had been more conſiderable.

At another Time, in two other Sorts of Turnip-Seed, it was found by counting, that an Ounce of one Sort contained 14702 Grains; and an Ounce of the other Sort no fewer than 14905 Grains.

It is credibly reported, that of late Years Turnips have been pretty frequently found growing in ſeveral Counties of this Kingdom, that have weighed above twice as much; one of which was ſeen at *Birmingham* about the Year 1710.

Of the Culture *of* Tobacco *in* Ceylan, *by Mr.* Strachan. n. 279. p. 1164.

IX. There are two Sorts of Tobacco, both which, they call *Dunkol*, the Signification is a Smoaking-Leaf; for *Dun* is Smoak, *Kol* a Leaf, the one they call *Hingele Dunkol*, or *Singele Dunkol*, for they make no Diſtinction of *H* and *S*; the other is called *Dunkol Kapada*, which Word *Kapada* ſignifies gelding, and is derived from the *Portugueſe*; which Tobacco, is very intoxicating, and much ſtronger than the former; it is the ſame Plant, the Difference is only that *Singeleſe* Tobacco has little attendance,

tendance, upon the other a great deal of Pains is taken, until it be fit for Uſe; and it is done after the following Manner:

They clear a little piece of Ground, in which they ſow the Seed of Tobacco, as the Gardeners here ſow Parſley and Coleworts; againſt the Time that this is ready for tranſplanting, they chooſe a piece of Ground, which they hedge about; when the Buffalo's begin to chew the Cud, they are put within this Hedge Ground, and let ſtand until they have done, and this they continue Day and Night, until the Ground be ſufficiently dunged; then the Ground is tilled with a Spade, in Form of a Pick-ax, ſuch as Carpenters uſe when they ſmooth Planks, by howing the Ground, and turning the ſame, and mixing the Dung among the Earth; when they have made the Ground ſmooth, they remove the Plants out of the Bed, wherein they were ſown, and ſet them in this Ground, about a Foot Diſtance one from another, and then they grow up almoſt like a Dock; when the Stem has got 15 Leaves, they cut off all the Tops of the Plants; if they deſire not to have the Tobacco to be very ſtrong, they let it grow until it have 18 or 20; if they will have it ſtronger, they top it when it has got 10 or 12 Leaves, not counting the 3 or 4 loweſt Leaves, which are neareſt the Ground, becauſe they never grow ſo big and good, as thoſe above them. Thus the Moiſture of the Ground being hinder'd from waſting in more Leaves, Flowers and Seed, all the ſaid Moiſture enters into the Leaves remaining, ſo that theſe Leaves will be 4 or 5 Times larger, fuller of Fatneſs, Strength and Virtue, than the Tobacco which is not ordered after this Manner. Now the Moiſture aſcending from the Root, being conſtrained within the Bounds of theſe Leaves, forces its Way betwixt the Stem and Leaves remaining, and ſends forth young Sprouts, and would grow forth in Branches, if no Care were taken to hinder. Therefore every 3 or 4 Days they go through all the Stems, and break off theſe Buds whenever they ſpring forth, and this they continue, until theſe Leaves be ripe (which takes as much Time as the *Singele* Tobacco does, which gets Flowers and ripe Seed, and then begins to wither and ſpoil, if no Uſe be made of it) which is known by the Thickneſs and Firmneſs.

Then before the Leaf begins to wither, and is green, they cut down the Stem together with the Leaves, and do bring them into their Houſes, and lay them in a Heap; and thus the Leaves will begin to ferment, turn hot, and ſweat, then when the Leaves begin to ſweat, they turn the innermoſt outmoſt, that they may eaſily ferment; otherwiſe the innermoſt would ferment too much, ſpoil, and rot: Thus the longer they lie in a Heap together, the Tobacco turns the more dark of Colour. When they think it has ſweat enough, they hang it aſunder upon Cords, till the Leaves be dry, then they ſeparate the Leaves from the Stalks, and lay them up in Bundles together, until they have Uſe for them.

Now the other Tobacco, called *Singele Dunkol*, is only ſown, and then planted, and has Liberty to grow, to ſhoot out, flower, and ſeed; thus all ripen together: Then it is cut down and caſt together in a Heap;

ſome

ſome will ferment too much, and rot, others will ferment not at all, and will remain green, although it be dry, and will have a ſmell of Hay or dry Graſs. The Soldiers, who delight to ſmoak a big Pipe full, and that frequently in one Day, do ſmoak this common ſort, ſome will mix ſome of the *Kapada* among it; the *Cingualeſes*, who ſmoak not ſo much at once, neither ſo frequently, do take a piece of the *Kapada*, and roll it together, then roll a piece of dry Leaf of the *Wattukan* Trees about this, and kindle it at one End, and ſuck at the other, until it be conſumed. Some do chew it among Betle, taking but very little at once.

Of a Tartarian Plant *call'd* Gin-ſeng, *&c. by Father* Jartoux, *taken from the Tenth Vol. of* Letters *of the Miſſionary* Jeſuits. n. 337. p. 237.

X. The Map of *Tartary*, which we made by Order of the Emperor of *China*, gave us an Opportunity of ſeeing the famous Plant *Gin-ſeng* or *Nin-zin*, ſo much eſteem'd in *China*, and ſo little known in *Europe*. Towards the End of *July* 1709, we arrived at a Village, not above four ſmall Leagues diſtant from the Kingdom of *Corea*, which is inhabited by thoſe *Tartars* called *Calca tatze*. One of theſe *Tartars* went and found upon the neighbouring Mountains four Plants of the *Gin-ſeng*, which he brought us entire in a Baſket. I took one of them, and deſigned it, as well as I could.

The moſt eminent Phyſicians in *China* have writ whole Volumes upon the Virtues and Qualities of this Plant, and make it an Ingredient in almoſt all Remedies which they give to their chief Nobility; for it is of too high a Price for the common People. They affirm, that it is a ſovereign Remedy for all Weakneſſes occaſion'd by exceſſive Fatigues either of Body or Mind; that it diſſolves pituitous Humours; that it cures Weakneſs of the Lungs, and the Pleuriſy; that it ſtops Vomitings; that it ſtrengthens the Stomach, and helps the Appetite; that it diſperſes Fumes or Vapours; that it fortifies the Breaſt, and is a Remedy for ſhort and weak Breathing; that it ſtrengthens the Vital Spirits, and increaſes Lymph in the Blood: In ſhort, that it is good againſt Dizzineſs of the Head, and Dimneſs of Sight, and that it prolongs Life in old Age.

No Body can imagine that the *Chineſe* and *Tartars* would ſet ſo high a Value upon this Root, if it did not conſtantly produce a good Effect. Thoſe that are in Health often make uſe of it to render themſelves more vigorous and ſtrong: And I am perſuaded, that it would prove an excellent Medicine in the Hands of any *European* who underſtands Pharmacy, if he had but a ſufficient Quantity of it, to make ſuch Trials as are neceſſary, to examine the Nature of it chymically, and to apply it in a proper Quantity according to the Nature of the Diſeaſe for which it may be beneficial.

It is certain, that it ſubtilizes, increaſes the Motion of, and warms the Blood; that it helps Digeſtion, and invigorates in a very ſenſible manner. After I had deſigned the Root, I obſerved the State of my Pulſe, and then took half of the Root, raw as it was, and unprepar'd: In an Hour after, I found my Pulſe much fuller and quicker; I had an Appetite,

tite, and found my ſelf much more vigorous, and could bear Labour much better and eaſier than before.

But I did not rely on this Trial alone, imagining that this Alteration might proceed from the Reſt that we had that Day: But four Days after, finding my ſelf ſo fatigued and weary that I could ſcarce ſet on Horſeback, a *Mandarin*, who was in Company with us, perceiving it, gave me one of theſe Roots: I took half of it immediately, and an Hour after I was not the leaſt ſenſible of any Wearineſs. I have often made Uſe of it ſince, and always with the ſame Succeſs. I have obſerved alſo, that the green Leaves, and eſpecially the fibrous Part of them chewed, would produce nearly the ſame Effect.

The *Tartars* often bring us the Leaves of *Gin-ſeng* inſtead of *Tea*; and I always find my ſelf ſo well afterwards, that I ſhould readily prefer them before the beſt Tea. Their Decoction is of a grateful Colour; and when one has taken it twice or thrice, its Taſte and Smell become very pleaſant.

As for the Root of this Plant, it is neceſſary to boyl it a little more than Tea, to allow Time for extracting its Virtue; as is practiſed by the *Chineſe*, when they give it to ſick Perſons, on which Occaſion they ſeldom uſe more than the fifth Part of an Ounce of the dryed Root. But as for thoſe that are in Health, and take it only for Prevention, or ſome ſlight Indiſpoſition, I would adviſe them not to make leſs than ten Doſes of an Ounce, and not to take of it every Day. It is prepared in this Manner: The Root is to be cut into thin Slices, and put into an Earthen Pot well glazed, and filled with about a Quarter of a Pint of Water *Paris* Meaſure: The Pot muſt be well covered, and ſet to boyl over a gentle Fire; and when the Water is conſumed to the Quantity of a Cupful, a little Sugar is to be mix'd with it, and it is to be drank immediately. After this, as much more Water is to be put into the Pot upon the Remainder, and to be boyled as before, to extract all the Juice and what remains of the ſpirituous Part of the Root. Theſe two Doſes are to be taken, one in the Morning, and the other at Night.

The Places where this Root grows are between the thirty ninth and forty ſeventh Degree of Northern Latitude, and between the tenth and twentieth Degree of Eaſtern Longitude, reckoning from the Meridian of *Pekin*. There is there a long Tract of Mountains, which the thick Foreſts, that cover and encompaſs them, render almoſt unpaſſable. It is upon the Declivities of theſe Mountains and in theſe thick Foreſts, upon the Banks of Torrents or about the Roots of Trees, and amidſt a Thouſand other different ſorts of Plants, that the *Gin-ſeng* is to be found. It is not to be met with in Plains, Vallies, Marſhes, the Bottoms of Rivulets, or in Places too much expoſed and open. If the Foreſt take Fire and be conſumed, this Plant does not appear till two or three Years after: It alſo lies hid from the Sun as much as poſſible; which ſhews that Heat is an Enemy to it. All which makes me believe, that if it is to be found in any other Country in the World, it may be parti-

particularly in *Canada*, where the Foreſt and Mountains, according to the relation of thoſe that have lived there, very much reſemble theſe.

The Places where the *Gin-ſeng* grows, are on every ſide ſeparated from the Province of *Quan tong* (which in our old Maps is called *Leao-tum*) by a Barrier of wooden Stakes, which incompaſſes this whole Province, and about which Guards continually patroll, to hinder the *Chineſe* from going out and looking after this Root. Yet how vigilant ſoever they are, their Greedineſs after Gain incites the *Chineſe* to lurk about privately in theſe Deſerts, ſometimes to the Number of two or three Thouſand, at the Hazard of loſing their Liberty, and all the Fruit of their Labour, if they are taken either as they go out of, or come into, the Province.

The Emperor having a Mind that the *Tartars* ſhould have the Advantage that is to be made of this Plant, rather than the *Chineſe*, gave Orders this preſent Year 1709 to ten Thouſand *Tartars*, to go and gather all that they could of the *Gin-ſeng*, upon Condition that each Perſon ſhould give his Majeſty two Ounces of the beſt, and that the reſt ſhould be paid for according to its Weight in fine Silver. It was computed, that by this Means the Emperor would get this Year about twenty Thouſand *Chineſe* Pounds by it, which would not coſt him above one fourth Part of its Value. We met by Chance with ſome of theſe *Tartars* in the midſt of thoſe frightful Deſerts: And their *Mandarins*, who were not far diſtant out of our Way, came one after anorher, and offer'd us Oxen for our Subſiſtence, according to the Commands they had received from the Emperor.

This Army of Herbariſts obſerved the following Order. After they had divided a certain Tract of Land among their ſeveral Companies, each Company, to the Number of an hundred, ſpreads itſelf out in a ſtraight Line to a certain fix'd Place, every Ten of them keeping at a Diſtance from the reſt. Then they ſearched carefully for the Plant, going on leiſurely in the ſame Order; and in this Manner in a certain Number of Days they run over the the whole Space of Ground appointed them. When the Time is expir'd, the *Mandarins*, who are encamp'd with their Tents in ſuch Places as are proper for the Subſiſtence of their Horſes, ſend to view each Troop, to give them freſh Orders, and to inform themſelves if their Number is compleat. If any one of them is wanting, as it often happens, either by wandering out of the Way, or being devoured by wild Beaſts, they look for him a Day or two, and then return again to their Labour as before.

The poor People ſuffer a great deal in this Expedition. They carry with them neither Tents nor Beds, every one being ſufficiently loaded with his Proviſion, which is only Millet parched in an Oven, upon which he muſt ſubſiſt all the Time of his Journey; ſo that they are conſtrain'd to ſleep under Trees, having only their Branches and Barks, if they can find them, for their Covering. Their *Mandarins* ſend them from Time to Time ſome Pieces of Beef, or ſuch Game as they happen

to

to take, which they eat very greedily and almoſt raw. In this manner theſe ten thouſand Men paſſed ſix Months of the Year; yet, notwithſtanding their Fatigues, continued luſty, and ſeemed to be good Soldiers. The *Tartars*, which were our Guard, did not fare better, having only what remained of an Ox, that was killed every Day, and had firſt ſerved fifty Perſons for their Subſiſtence.

A, ſhows the *Root* of the Plant; which, when waſh'd, was white and a little rugged and uneven, as the Roots of other Plants generally are. Fig. 56.

B, *C*, *D*, repreſent the Length and Thickneſs of the Stalk; which is ſmooth and pretty round, of a deepiſh red Colour, except near its Beginning at *B*, where it is whiter, by Reaſon of its Nearneſs to the Ground.

D, is a ſort of Knot or Joynt, made by the ſhooting out of four Branches, which all riſe from the ſame Center, and divide from another at equal Diſtances, and at the ſame Height from the Ground. The underſide of the Branch is green, mix'd with white; the upper Part is much like the Stalk, of a deep red, inclining to the Colour of a Mulberry. Theſe two Colours gradually decreaſe and unite together on the ſides in a natural Mixture. Each Branch has five Leaves. It is remarkable, that theſe Branches ſeparate from each other at equal Diſtances, as well in Reſpect of themſelves, as of the Horizon, and make with their Leaves a circular Figure, nearly parallel to the Surface of the Ground.

Tho' I have finiſh'd the Deſign but of half of one of the Leaves at *F*, yet any one may eaſily conceive and perfect the reſt in the ſame Manner. I do not know that ever I ſaw Leaves, ſo large as theſe, that were ſo thin and fine: Their Fibres are very diſtinguiſhable; and on the upper ſide they have ſome ſmall whitiſh Hairs. The Skin between the Fibres riſes a little in the middle above the Level of the Fibres. The Colour of the Leaf is a dark green above, and a ſhining whitiſh green underneath. All the Leaves are ſerrated, or very finely indented on the Edges.

From *D*, the Centre of the Branches, there riſes a ſecond Stalk *D E*, which is very ſtraight and ſmooth, and whitiſh from Bottom to Top, bearing a Bunch of round Fruit of a beautiful red Colour. This Bunch was compoſed of twenty four Berries, two of which are here drawn, marked 9, 9. The red Skin that covers the Berry, is very thin and ſmooth: It contains within it a white ſoftiſh Pulp. As theſe Berries were double (for they are ſometimes found ſingle) each of them had two rough Stones, ſeparated from one another, of the Size and Figure of our common Lentils, excepting that the Stones have not a thin Edge like Lentils, but are almoſt every where of an equal Thickneſs. Each Berry was ſupported by a ſmooth, even, and very fine Sprig, of the Colour of thoſe of our ſmall red Cherries. All theſe Sprigs roſe from the ſame Centre, and ſpreading exactly like the Rays of a Sphere, they make

the Bunch of Berries, that they bear of a circular Form. This Fruit, is not good to eat. The Stone is like the Stones of other common Fruit; it is hard, and incloſes a Kernel. It is always placed upon the ſame Plan or Level with the Sprig that bears the Berry. From whence it is, that the Berry is not round, but a little flat on each ſide. If it be double, there is a kind of Depreſſion or hollow Place in the middle, where the two Parts unite. It has alſo a ſmall Beard at Top, diametrically oppoſite to the Sprig on which it hangs. When the Berry is dry, there remains only a ſhrivel'd Skin that ſticks cloſe to the Stones, and is then of a dark red, or almoſt black Colour.

This Plant dyes away, and ſprings again every Year. The Number of its Years may be known by the Number of Stalks it has ſhot forth, of which there always remains ſome Mark; as may be ſeen in the *Figure* by the Letters *b*, *b*, *b*, &c. From whence it appears, that the Root *A* was ſeven Years old, and that the Root *Fig.* 57. was fifteen.

As to the Flower, not having ſeen it, I can give no Deſcription of it. Some ſay that it is white and very ſmall: Others have aſſured me, that this Plant has none, and that no Body ever ſaw it. I rather believe that it is ſo ſmall, and ſo little remarkable, that they never took Notice of it: And what confirms me in this Opinion, is, that thoſe that look for the *Gin-ſeng*, having Regard to, and minding only the Root commonly neglect and throw away all the reſt of the Plant, as of no Uſe.

There are ſome Plants, which beſide the Bunch of Berries I have deſcribed, have alſo one or two Berries like the former, plac'd an Inch or an Inch and a half below the Bunch. And when this happens, they ſay, if any one takes Notice of the Point of the Compaſs that theſe Berries direct to, he can't fail of finding the Plant at ſome Places diſtant that way, or thereabouts. The Colour of the Berries, when the Plant has any, diſtinguiſhes it from all others, and makes it remarkable at firſt Sight: But it ſometimes happens that it bears none, tho' the Root be very old; as that repreſented *Fig.* 57. had no Fruit, tho' it was in its fifteenth Year.

Fig. 57.

They having ſowed the Seed in vain, without its producing any Plant, might probably give Occaſion to this Story, which is current among the *Tartars*. They ſay that a Bird eats it as ſoon as it is in the Earth, and not being able to digeſt it, it is putrified in its Stomach, and afterwards ſprings up in the Place, where it is left by the Bird with its Dung. I rather believe that the Stone remains a long Time in the Ground, before it ſhoots out any Root. And this Opinion of mine ſeems the more probable, becauſe there are found ſome Roots, which are not longer, and not ſo big as ones little Finger, tho' they have ſhot forth ſucceſſively, at leaſt ten Stalks in as many different Years.

Tho' the Plant I have here deſcribed had four Branches, yet there are ſome that have but two, others but three, and ſome that have five or ſeven; which laſt are the moſt beautiful: Yet every Branch has always

five

five Leaves, as well as this here figur'd, unleſs the Number has been diminiſh'd by any Accident. The Height of the Plants is proportionable to their Bigneſs and the Number of their Branches. Thoſe that bear no Fruit, are commonly ſmall and very low.

The Root, the larger and more uniform it is, and the fewer ſmall Strings or Fibres it has, is always the better; on which Account, that marked *Fig.* 57. is preferable to the other. I know not for what reaſon the *Chineſe* call it *Gin-ſeng*, which ſignifies *the Repreſentation* or *Form of Man:* Neither I my ſelf, nor others who have ſearched and inquired into it on purpoſe, could ever find it had any Reſemblance to the Signification of its Name; though among other Roots there may now and then be found ſome which by accident have very odd Figures. The *Tartars* with more Reaſon call it *Orhota*, which ſignifies *the chief of Plants.*

It is not true, that this Plant grows in *China*, as Father *Martini* affirms from the Authority of ſome *Chineſe* Books, which make it to grow on the Mountains of *Yong-pinfou* in the Province of *Peking*. They might eaſily be led into this Miſtake, becauſe that is the Place where it firſt arrives when it is brought from *Tartary* into *China*.

Thoſe that gather this Plant, preſerve only the Root, and bury together in ſome certain Place in the Earth, all that they can get of it, in ten or fifteen Days Time. They take Care to waſh it well, and cleanſe it with a Bruſh from all extraneous Matter; then they dip it into ſcalding Water, and prepare it in the Fume of a ſort of yellow Millet, which communicates to it part of its Colour. The Millet is put into a Veſſel with a little Water, and boils over a gentle Fire; the Roots are laid upon ſmall tranſverſe pieces of Wood over the Veſſel, and are thus prepared, being covered with a Linnen-cloath or ſome other Veſſel placed over them. They may alſo be dry'd in the Sun, or by the Fire; but then, though they retain their Virtue well enough, yet they have not that yellow Colour which the *Chineſe* ſo much admire. When the Roots are dry'd, they muſt be kept cloſe in ſome very dry Place; otherwiſe they are in Danger of corrupting, or being eaten by Worms.

[*This Plant* (Gin-ſeng) *grows to the Height of about* 18 *Inches.*]

XI. *Araliaſtrum* is a *Genus* of Plants, whoſe *Flower* A*, is complete †, regular, polypetalous, and hermaphrodite, ſtanding on the *Ovary* B. The *Ovary*, which is crown'd by a *Calyx* cut into ſeveral Parts, becomes a Berry D, in which are, for the moſt part, two flat Seeds, like a Semicircle, which both together repreſent a ſort of a Heart. Add to this, the Stalk, which is ſingle, ending in an Umbel, of which each Ray bears but one Flower. Above the Middle of the Stalk come out ſeveral *Pedicles*, (as on that of the *Anemone*) on the Extremities of which grow ſeveral Leaves like Rays, or like an open Hand.

A new Genus *of* Plants, *of which the* Ginſeng *is a* Species. *Communicated by Mr.* Vaillant *to Dr.* W. Sherrard. n. 354. p. 705.

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* *Vid.* ARALIA *Inſt. rei herb.* Tab. 154.

† Complete, *that is to ſay, that has a* Calyx.

The Species *of this* Genus *are*, [1. *Araliaſtrum Quinquefolii folio, majus*, Nin-zin *vocatum D.* Sarrazin. *Gin-ſeng*. Des lettres edifiantes & curieuſes, *Tom.* X. *pag.* 172.

2. *Araliaſtrum Quinquefolii folio, minus*. D. Sarrazin. *Plantula Marilandica, foliis in ſummo caule ternis, quorum unumquodque quinquefariam dividitur, circa margines ſerratis*. N. 36. Raii Hiſt. III. 658.

3. *Araliaſtrum Fragrariæ folio, minus*. D. Vaillant. *Naſturtium Marianum Anemones ſylvaticæ foliis, enneaphyllon, floribus exiguis*. Pluk. Mantiſſ. 135. Tab. 435. Fig. 7.

To ſhew wherein *Araliaſtrum* differs from *Aralia*, (from whence it takes its Name) 'tis convenient to give alſo the Character of this laſt *Genus*, ſuch as Mr. *Vaillant* eſtabliſh'd it, in his Demonſtrations of the Year 1717.

Aralia * is altogether like the *Araliaſtrum*, as to the Structure and Situation of its Flower, but its Berry conſiſts of five Seeds plac'd round an *Axis*. Moreover, its Leaves are branched, almoſt like thoſe of *Angelica*; and its Stalks (which in ſome *Species* are naked, and in others have Leaves ſet alternately) bear each ſeveral Umbels at their Top, in the Form of a Bunch of Grapes.

The Species *of* Aralia *are*, [1. *Aralia caule aphyllo, radice repente*. D. Sarrazin. *Chriſtophoriana Virginiana Zarzæ radicibus ſurculoſis & fungoſis, Sarſaparilla noſtratibus dicta*. Pluk. Almag. 98. Tab. 238. Fig. 5. *Zarſaparilla Virginienſibus noſtratibus dicta, lobatis umbelliferæ foliis, Americana*. Ejuſd. Almag. 396.

2. *Aralia caule folioſo lævi*, D. Sarazzin. *Aralia Canadenſis*. Inſt. rei Herb. 300.

3. *Aralia caule folioſo & hiſpido*, D. Sarazzin.

4. *Aralia arboreſcens ſpinoſa*, D. Vaillant. *Angelica arboreſcens, ſpinoſa, ſeu Arbor Indica, Fraxini folio, cortice ſpinoſo*, Raii Hiſt. II. 1798. *Chriſtophoriana arbor aculeata Virginienſis*, Pluk. Almag. 98. Tab. 20.

All the *Species* of theſe two *Genera*, except the laſt of each of them, are common in *Canada*. The Inhabitants of that Colony, and thoſe of *Virginia*, call the firſt *Species* of *Aralia* by the Name of *Sarſaparilla*, becauſe its Roots have almoſt the ſame Figure and Virtues.

Mr. *Sarrazin* writes, that he had a Patient who had been cured of an *Anaſarca*, about two Years before, by the Uſe of a Drink made of theſe Roots; and aſſures us, that the Roots of the ſecond *Species*, well boil'd and apply'd by way of *Cataplaſm*, are very excellent for the curing of old Ulcers; as alſo the Decoction of them, with which they bathe and ſyringe the Wounds. He does not at all doubt, but the Virtues of the third *Species* (which I ſhall briefly deſcribe) are the ſame with thoſe of the ſecond.

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* *Vid. Inſt. rei Herb.* 300. Tab. 154.

Its

Its Roots creep, and ſend forth Stalks, which riſe commonly to the Height of a Foot and half, and ſometimes to two Foot; the bottom part of them is rough, with reddiſh, ſtiff, and prickling Hairs. Theſe Stalks are ſet from the Bottom to almoſt the Top (which are divided ſucceſſively into ſeveral naked Branches charg'd with Umbels) with branch'd alternate Leaves, almoſt like thoſe of *Podagraria hirſuta Angelicæ folio & odore* D. Vaillant; which Plant is grav'd in the ſecond Tome of *Boccone*'s *Muſæum*, by the Name of *Cereſolium rugoſo Angelicæ folio, Aromaticum*, Tab. 19. and in *Rivini* by that of *Myrrhis folio Podagrariæ*.

Of a New Plant *call'd* Iquetaia, *the ſame with* Scrophularia Aquatica, *by Monſ.* Marchand. n. 273. p. 1103.

XII. Monſieur *Marchand* acquainted the Aſſembly of the *Academy of Sciences* in *France*, with the Diſcovery of a new *Simple*. The firſt that brought it into Reputation, was a *Portugueze Surgeon*, who having lived many Years in *Brazil*, diſcovered the Virtues of this Plant; after returning into *Portugal* with a Deſign to raiſe a great Trade with it, he ſent ſeveral *Specimens* of it every where. He called the Plant *Iquetaia*, and attributed to it no leſs Virtues than the Cure of *Apoplexies*, *Pleuriſies*, and *Intermitting Fevers*. He added one Thing, which though more particular, yet ſeemed more probable, which was, that the Leaves infus'd with *Senna*, took from it its diſagreeable Taſte and Smell, without altering any Thing of its *Purgative* Quality. The *Samples* that he ſent, were not in ſufficient Quantity to make Experiment on the Diſtempers, he ſaid it was proper for; but there was enough to try, whether they had the Virtue to correct the Taſte and Smell of *Senna*. Therefore there was infus'd two *Drachms* of it, with as much *Senna* in a *Chopine* of Water, and the Experiment confirm'd the Matter of Fact: Being deſirous to know what *Species* of Plant it was, and it being impoſſible to diſcover it by the Leaves, which the *Portugueſe Surgeon* had taken ſo much Care to cut very ſmall, Monſieur *Homberg*, who had ſome of it ſent him, perceived ſome Seeds ſwimming on the Water, in which they were infus'd; and taking up as many as he could of theſe Seeds, gave them to Monſieur *Marchand*, who ſowed them; from whence grew up a Plant, which we need not go to *Braſil* to ſeek, it grows in *Europe*; nor need we go out of *France* to find it; nay, we may have it all round *Paris*; 'tis the *Scrophularia aquatica*. To be the more certain of it, there was ſome of our *Scrophularia* ſowed on a Bed, and ſome of the other Seed on another, and there was obſerved but ſome ſmall Differences, which may be well attributed to the different Culture and Soil. There was likewiſe try'd the Virtue of our *Scrophularia*, and it was found to have the ſame Effect, in taking away the Taſte and Smell of *Senna*, Monſieur *Marchand* concluded from this Diſcovery, that it was more fit to labour to know the Remedies that are in our own Land, than to run over all the Earth in queſt of that, with much Labour and Charge, which we may have for nothing at Home, if we took the Pains to ſearch: And added, that a knowing *Botaniſt* (meaning his Father) after many long Tra-

Travels avowed, that there might be found in all Countries Remedies for all Diſeaſes, and that having apply'd himſelf to this Matter, he had diſcovered a good Number of Simples commonly to be found, that had great Virtues, of which he had graved the Plates. He named among others, the *Achillea Montana Penæ*, which ſmoaked in a Pipe as *Tobacco*, conſiderably eaſes an *Aſthma*.

Of the Attmella *and its* Lithontriptic *Virtue, by Dr.* P. Hotton. n. 268. p. 760.

XIII. *Attmella*, *Acemella*, & *Hacmella*, iſtis enim nominibus miſſa mihi Anno 1691 ſemina ex Inſula *Ceylon*, ubi naſcitur & familiaris eſt.

Ipſa Planta, quam colui Anno 1692, Flores fert, in Caulium ſummis, ex multis Floſculis tubuloſis coagmentatos, in caput coactos, & Perianthio Hexaphyllo aut Polyphyllo ſuffultos, perquam ſimiles Chryſanthemo Curaſſavico alato caule, flore Aurantio (cujus Icon extat apud *Pluknet* Phytog. in Par. Batavo *Hermanni*, Horto Monſpel *Magnol.* & *Volkameri* Flora Noribergenſi) ſed luteolos; quibus excuſſis ſequuntur ſemina ex fuſco griſea, longa, plana, ſummâ ſui parte duplici ariſtâ prædita, ipſis floſculis ſubjecta: Caules edit quadratos, Foliis conjugatis *Lamii* aut *Urticæ* longioribus & acriuſculis veſtitos, ex quibus conjicitur ſpectare hanc plantam indubie ad *Corymboſarum* gentem & genuinam eſſe ſobolem ejus generis, quod *Bidens* a ſemine bidente vocat *Cæſalpinus*, eumque ſecutus *Tournefortius*. Quare cum hactenus nomine careat hæc planta, hoc ex ipſius plantæ ingenio ei imponendum cenſeo.

Bidens Urticæ folio Lithontriptica *Zeylanica*. Inter omnia enim Medicamenta quæ in comminuendo *Calculo* valere perhibentur, planta hæc nuperis annis facta eſt celeberrima, inter noſtros homines qui in memoratâ inſulâ vivunt, & noviſſimè quoque apud nos multam nacta eſt celebritatem.

Miles quidam, qui primus Anno 1690. *Societati* noſtræ *Indicæ* indicium hujus herbæ dedit, profitebatur ſe pluſquam centum ægros ejus ope liberaſſe a *Calculo* & *Nephriticis* doloribus: quam & cum ſucceſſu uſurpatam in duobus ægris calculoſis teſtantur in literis eodem anno ad *Societatem Indicam* datis Gubernator & Supremus *Batavorum* Conceſſus in Inſulâ *Ceylon*; aiunt enim in iis deturbatas expulſaſque fuiſſe multas arenulas, minutoſque calculos abſque ullo fere dolore.

Primus *Noſocomii* urbis *Colombo*, quæ ſita eſt in memoratâ Inſulâ, Chirurgus, in literis Anno 1699. ad me datis, in rei veritate teſtari ſe poſſe aſſerit, efficacius medicamentum contra Calculum & Nephriticos dolores repertum hactenus non fuiſſe, qui & porro addit tres ejus ſpecies a ſe multâ inveſtigatione inventas; quarum *prima* foliis amicitur dilutè virentibus & ſemen producit itidem Luteum: *Secunda* folia edit ſaturè virentia, & ſemen producit itidem luteum: *Tertia* ſemen nigrum profert & longe majoribus foliis veſtitur quam reliquæ duæ, quas virtute præſtantiſſimas eſſe aſſerit; denique ſubjungit fertiliſſimam eſſe hanc plantam, quæque pluſquam decem millia ſeminum gignit.

Hujus uſurpantur folia, ſemen, quod præ cæteris partibus laudat præfectus ille noſter noſocomii *Zeylanenſis*, Radix, Caules & Rami.

Fig. 48

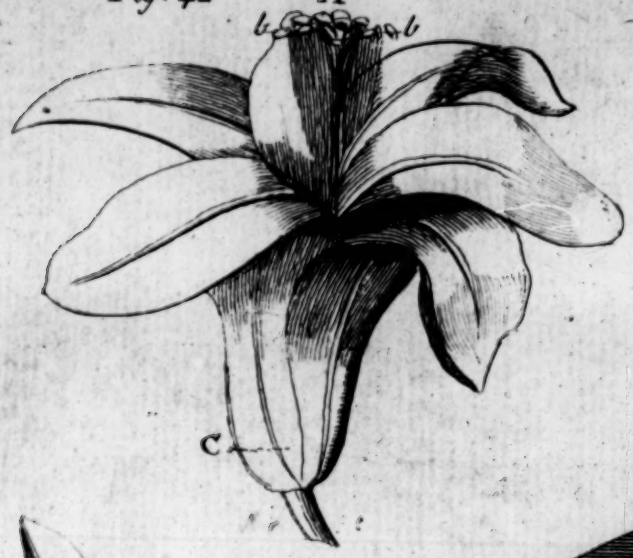

Fig. 50

Fig. 51

Fig. 49

Fig. 46

Fig. 47.

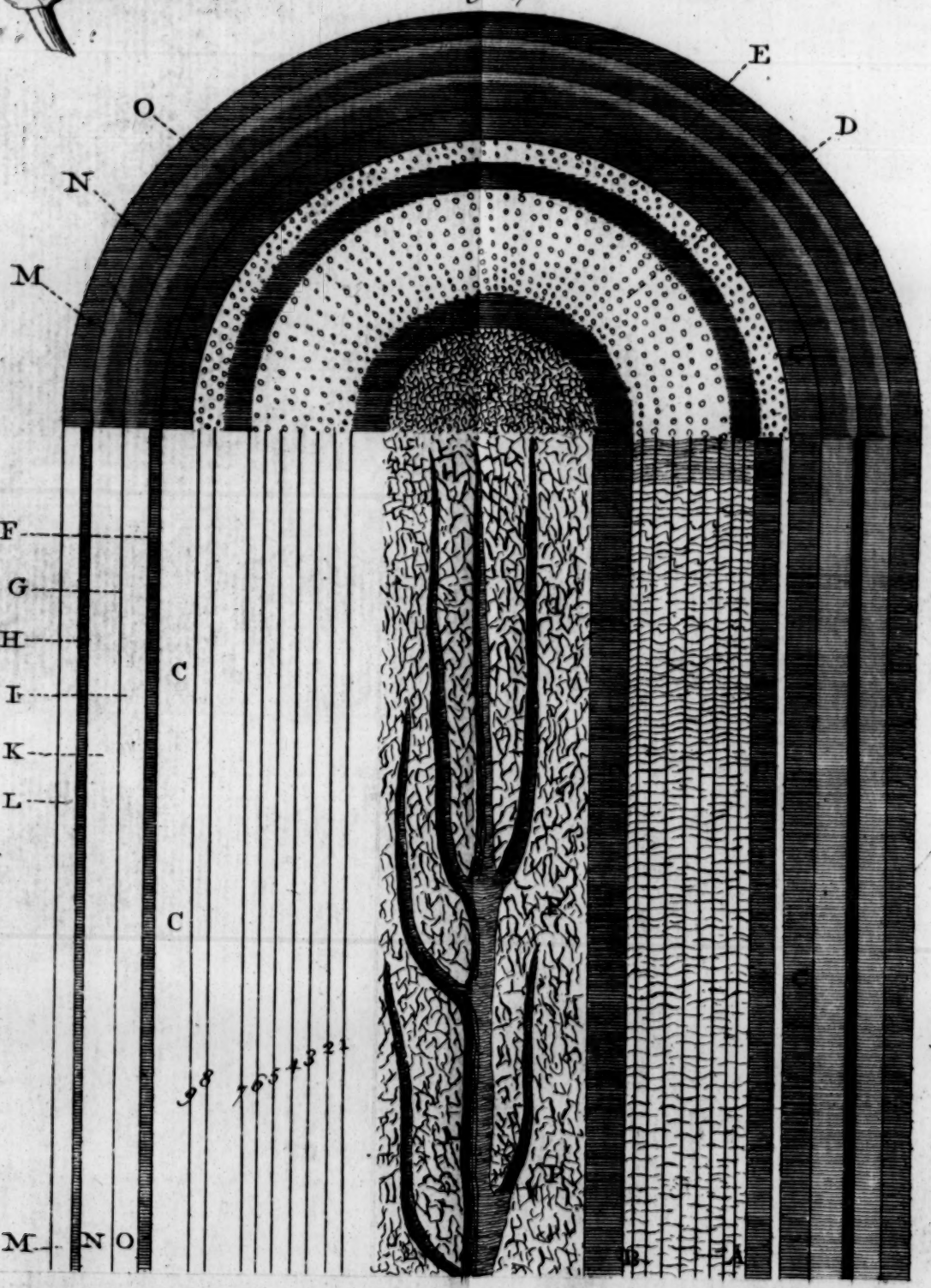

Fig. 52.

Fig. 53.

Fig. 54.

Fig. 55.

Fig. 56.

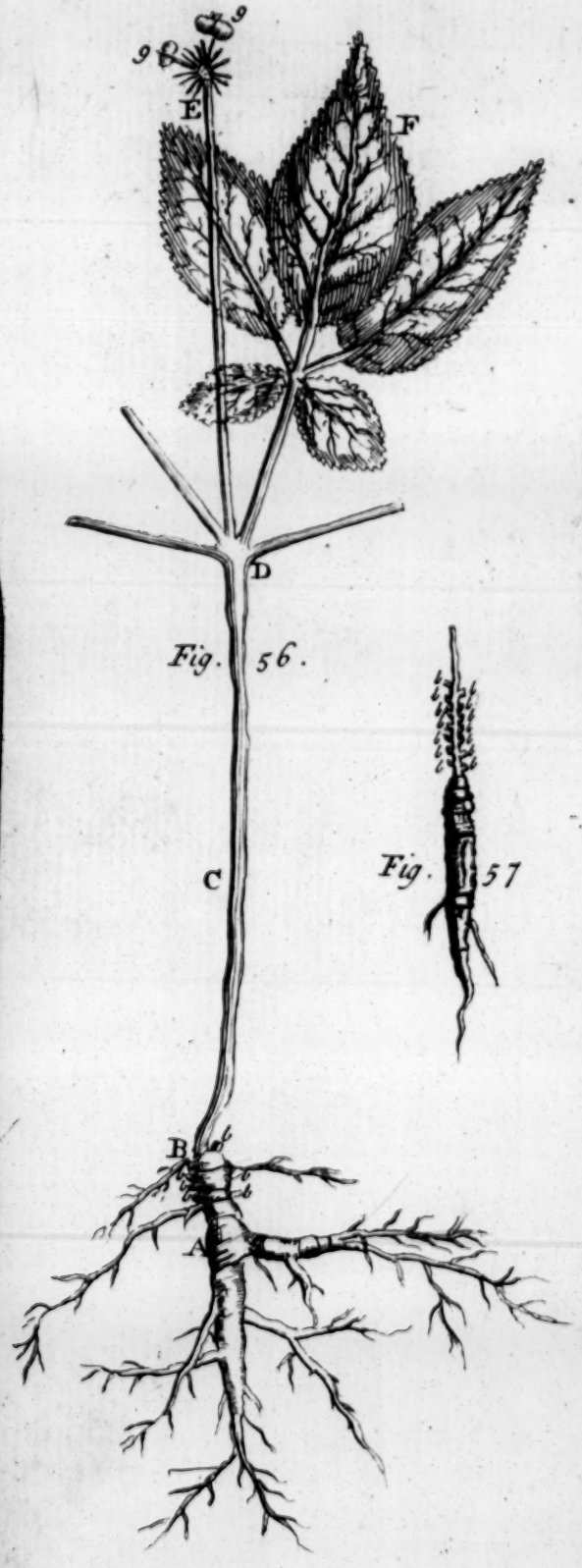

Fig. 57

Folia Lecta antequam flores prodeunt in umbrâ ſiccata, & in pulverem comminuta dantur in convenienti vehiculo aut aqua calida infunduntur, bibiturque ea infuſio inſtar infuſionis herbæ *The* infunduntur & *Spir. Vini*, & paratur per deſtillationem Spiritus ex Radice, caulibus & ramis.

Flores, Radices, Extractum, & Sal in *Pleuritide*, *Colica*, & *Febribus* feliciter ſe uſurpaſſe teſtatur alius quidam Noſocomii *Zeylonenſis* præfectus.

D. *Colombo* laudat quoque in ſuis litteris a vi lithontripticâ Cortices radicum, ipſaſque Radices herbæ cujuſdam *Mangul Caranda Pottu* Zeylanenſibus dictæ, at, quæ illa ſit, me latet. *Another* Plant.

XIV. *Peru Bark* comes from a Tree of about the Bigneſs of a Plúmb Tree, with Leaves like Ivy, but not quite ſo big, and are always green. The *Indians* call it *Querango*. It is gather'd in Autumn, and the Rind taken off all round, as well from the Trunk as Boughs, which grows again in four Months, as *Cork* does: The Trunk is about the Bigneſs of a *Man's Thigh*; it bears a Fruit not unlike a *Cheſnut*, (except in its outer Rind or Shell) which is properly called *China China*, and is eſteem'd by the Natives beyond the Bark taken from the Trunk or Boughs. This Account I receiv'd from an ingenious Apothecary at *Cadiz* in *Spain*, A.D. 1694. who had liv'd in *Peru*, and had ſeen it growing and gather'd it ſeveral times. From this Hiſtory I made this Obſervation, that probably *China China*, or the Rind of the Fruit, was firſt only in Uſe, and the more powerful Medicine us'd in ſmaller Quantities, and that the Bark of the Tree came not into Uſe, till ſome Time after; when the Virtues of it known in *Europe*, occaſioned a greater Demand for it. *Of the* Jeſuit's Bark, *by Dr.* W. Oliver. n. 290. p. 1596.

XV. Of the *Walnut-Tree* Authors ſeem to have known but ſix *Species*, tho' I can reckon nine. They confounded (unleſs I am deceiv'd) with the *common ſort*, that which the Country People call *Noix Angleuſes*, which one may call *Nux Juglans putamine duriſſimo*, which appears to me to be that which in *Hermolaus*, and in the *Hiſtoria Lugdunenſis* is called *Moratiæ Moracillæ*, and which *Cæſalpin* calls *Surdæ*. *A New Kind of* Walnut-Tree, *&c. by Mr.* Reneaume. n. 273. p. 908.

I don't ſee that the ſame Authors have diſtinguiſh'd another Species, which might be call'd *Nux Juglans fructu præcoci*, becauſe they are ſooner ripe than the others, and eaten about the Feaſt of St. *John en Cerneaux*, which has given them, amongſt the Country People, the Name of *Noix Joanneties*. As for that Species I am to treat upon, I can't find any Author that knew of it, and therefore I ſhall call it *Nux Juglans, folio eleganter diſſecto*, or *Acanthi-folia*.

The Oil which is preſſed out of the Walnut-Tree, in certain Provinces is us'd inſtead of Butter and Oil-Olive. In *Berry*, where they have very good Wool, and where they trade very much in Cattle, they have yet but very little Butter; and that little which they have, is worth nothing, and is very dear; ſo that they uſe Nut-Oil in dreſſing their Meat to eat. For this Reaſon there are an infinite Number

of

of Walnut-Trees planted in the middle of the plough'd Lands, in ſuch ſort, that afar off one would take theſe Lands for Woods of Walnut-Trees.

The Want of theſe Trees in this Country obliges the Inhabitants to cultivate them, and they take care to nouriſh them in particular Places, as in a ſort of Nurſery, in order to plant them a-freſh when they die, whether it be of Age (which is rare) or whether they decay, or that they are fell'd, for the Wood to work with.

The laſt *Autumn*, two Leagues from *Selles* in *Berry*, in the Pariſh of *Lis*, as I walked in an Orchard, looking upon ſome Plants near a Place where they bred up a vaſt Number of young Walnut-Trees, I perceiv'd in the middle a ſort of Leaf, (or Foliage) which I had never taken Notice of before. I went thither forthwith, and having examin'd it, as I knew not the Subſtance of this Leaf, I taſted it. The Taſte, Smell, Wood and Figure of the Tree, perſuaded me to believe that it was a Walnut-Tree, and I concluded that this was one, tho' I did not remember that I had ever read, or heard of any ſort like this.

This Tree is very young, and did never yet bear any Fruit, perhaps, becauſe it may be *(in a manner)* choak'd up, and that there is neither Air nor Nouriſhment enough, by Reaſon of the great Number of other Walnut-Trees, which grow round about it. It is near ſix Foot high, and two Inches Diameter at the Bottom. 'Tis adorned at the Top with many Branches, and (as the Country People ſaid) was about eight or nine Years old, and that they had always found its Leaves like thoſe which I ſaw.

The *(common)* Walnut-Tree bears its Leaves by Pairs, upon a Stalk, which terminates with a like Leaf, that is ordinarily bigger than the reſt: And it has very ſeldom above three Pairs upon each Stalk.

This has ſometimes four or five Pairs, and ſometimes more, which are one while oppoſite, another while alternate, altho' its Leaves appear ſmaller than thoſe of the common Walnut-Tree, becauſe of the Cuttings or *Slaſhes*. They are nevertheleſs as big, if one minds their Circumference taken from the Extremities of theſe *Slaſhes*.

The firſt Pair, and ſometimes the ſecond, are leſs *cut* than the reſt, being ſo only upon the Circumference: but the others are cut ſo deep, that it looks as if the Nerve in the middle of the Leaf was only a Stalk; and the *Cuts* of the Leaves are ſometimes by Pairs, ſometimes ſingle on one ſide. Theſe Leaves are ſometimes forked at the End, and ſometimes end with a Point. There are alſo ſome Places, where it looks as if the Leaf was torn on Purpoſe, almoſt like the *Angelica Canadenſis, foliis quaſi præmorſis*. There are others, where it ſeems that they are double, as if the Stalk or the Nerve was winged, juſt as the winged Stems, or Trunks, or *Caules alati*. All theſe Cuts and Slaſhes are not like Indentures or Notches, but finiſh with a Round. And notwithſtanding all theſe Irregularities, they look ſo pretty, that I can't compare them better *(to any thing)* than thoſe wrought Leaves, which ſerve for

for Ornaments to the Painters, almoſt like thoſe which adorn the Capital of *(Columns of)* the *Corinthian* Order, or that which in Heraldry they call *the Mantles*, or that which the Botaniſts term *Acanthus* or *Branca Urſina*, which is the firſt Original of this ſort of Ornament.

Dalechamp has obſerv'd an Aereal Honey of a yellowiſh Colour upon the Leaves of a Walnut-tree, during the greateſt Heats of the Summer; which can be nothing but an Effect of the Tranſpiration of this Tree, as of all other Trees, wherein the ſame thing is to be found; as I prov'd in a Diſcourſe to the *Academy* laſt Year, in ſpeaking of the *Sycamore*.

XV. *Papers Omitted.*

1. An Account of Mr. *Sam. Brown*'s (a Phyſician at *Fort St. George*) *Third* Book of *Eaſt-India* Plants, with their Names, Virtues, Deſcriptions, *&c.* by Mr. *J. Petiver*. *n.* 271. *p.* 843.

2. An Account of the *Fourth* Book of the ſame. *n.* 274. *p.* 927.

3. ——— of the *Fifth* Book. *n.* 276. *p* 1007.
4. ——— of the *Sixth* Book. *n.* 277. *p.* 1055.
5. ——— of the *Seventh* Book. *n.* 282. *p* 1251.
6. ——— of the *Eighth* Book. *n.* 299. *p* 1952.

7. *G. J. Camelli* de *Plantis Philippenſibus Scandentibus Tractatus*, ſent to Mr. *Petiver*. To which is added, a *Catalogue* of *Herbs* he formerly ſent him, the *Deſigns* of which are *deſcrib'd* by Mr. *J. Ray* in the *Appendix* to his *Third* Volume of *Plants*. *n.* 293. *p.* 1707.

8. *G. J. Camelli* de Plantis *Philippenſibus* Scandentibus, Pars *Secunda*. *n.* 294. *p.* 1763.

9. ——— Pars *Tertia*. *n.* 295. *p* 1809.
10. ——— Pars *Quarta*. *n.* 296. *p.* 1816.

11. An Account of ſeveral Rare *Plants* lately obſerved in ſeveral curious Gardens about *London*, and particularly the *Company* of *Apothecaries* Phyſic Garden at *Chelſea*, by Mr. *J. Petiver*, in Seven Tracts. *n.* 332. *p* 375. *n.* 333. *p.* 416. *n.* 337. *p.* 33, 177. *n.* 343. *p.* 229. *n.* 344. *p.* 269. *n.* 346. *p.* 353.

XVI. *Accounts of Books Omitted.*

1. The whole *Art* of *Huſbandry*, by *John Mortimer* Eſq; 8*vo*. *n.* 210. *p.* 2442.

*n.*285. *p.*1411. 2. *Gazophylacii Naturæ & Artis* Decas. In quâ *Animalia* Quadrupeda, Aves, Piſces, Reptilia, Inſecta, Vegetabilia; item *Foſſilia*, Corpora marina, & Stirpes Minerales, è Terrâ eruta; *Lapides* figura inſignes, &c. *Deſcriptionibus* brevibus & *Iconibus* illuſtrantur. Hiſce annexa eſt Supellex *Antiquaria*, Numiſmata, Gemmæ exciſæ & Sculpturæ, Opera *Figulina*, Lucernæ, Urnæ, Inſtrumenta varia, Inſcriptiones, Buſta, reliquaq; ad Rem *Priſcam* ſpectantia; item Machinæ, Effigies clarorum *Virorum*, omniaq; Arte producta. A *Jacobo Petiver*, R. S. S.

*n.*331. *p.*344. 3. *Gazophylacii Naturæ & Artis*, &c. Vol. I. in V Decadibus, per *J. Petiver.*

*n.*306. *p.*2253. 4. *Samuelis Dale*, *Pharmacologiæ* ſive *Manuductionis* ad Materiam Medicam *Supplementum*; Medicamenta *Officinalia* complectens: Ut & Notas *Generum* Characteriſticas, *Specierum* Synonyma, Differentias, & Vires. Cum duplici Indice, generali Altero nominum & ſynonymorum præcipuorum; Altero Anglico-Latino, in Gratiam Tyronum. 12*mo.* *Lond.* 1705.

n. 325. *p.* 35. 5. Index *Plantarum* Horti *Lugduno-Batavi*, per *Hermannum Boerhaven.* Lugd. Bat. 1710. 8*vo.*

n. 345. *p.*350. 6. *Ludovici Ferdinandi Marſilii* Diſſertatio de *Generatione Fungorum.* Romæ 1710. 8*vo.*

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THE END.